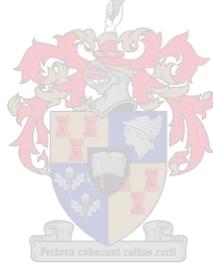


**An examination of Ethanol Gelfuel as a Sustainable  
alternative to Fossil Fuel use in Informal Settlements.**

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**Thesis presented in partial fulfilment of the  
requirements for the degree of Master of Philosophy  
in Sustainable Development Planning and  
Management at the University of Stellenbosch.**



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**DECEMBER 2007**

**DECLARATION**

**I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.**

**DATE** 24.11.2007

## ABSTRACT

Socio economic factors arising from a combination of a legacy of apartheid, rapid urbanization and dramatic levels of poverty force many South Africans living in shack environments to make energy choices that are often unsafe and unsustainable. This study sets out to establish why this is the case and then to determine the viability of an alternative energy carrier, an ethanol based gel fuel. The aim was to ascertain through a set of indicators the levels of sustainability of the product both under lab conditions and then through a pilot study in the Joe Slovo Informal settlement in Cape Town.

Hundreds of thousands of Informal settlement dwellers rely on paraffin to meet daily energy requirements and suffer dramatic fires, child poisonings and the noxious fumes that come from burning a fossil fuel in closed cramped environments. Although this work examines in great depth the reasons behind paraffin choice specifically within the Western Cape it also provides a commentary on other energy carriers used throughout the country. The purpose of both the pilot and lab study were to present the empirical evidence backed by a social commentary largely justified by the available literature into the need for providing more sustainable energy choices particularly for the poor.

Critical to the intentions of the outcomes of the document was to ascertain and measure the sustainability of ethanol Gelfuel and its potential future utilization. This assessment examines the economic, social and environmental parameters of the product under current conditions and then sets out to establish what conditions and criteria are required for its future distribution. Although the evidence regarding a definitive answer on the future of gel fuel in South African environments could not comprehensively be established through a single work such as this, it is hoped that this thesis and other limited material on the subject act as inspiration towards future research in this field.

## OPSOMMING

Sosio-ekonomiese faktore wat uit 'n kombinasie van die nalatenskap van apartheid, snelle verstedeliking en dramatiese vlakke van armoede ontstaan het, verplig baie Suid-Afrikaners wat in plakkersbuurtes leef om energiekeuses te doen wat dikwels onveilig en nie volhoubaar is nie. Hierdie studie beoog om vas te stel waarom dit die geval is en vervolgens om die lewensvatbaarheid van 'n alternatiewe energiedraer – 'n etanolbasis-jelbrandstof – te bepaal. Die doel was om deur middel van 'n stel aanwysers die vlakke van volhoubaarheid van die produk onder laboratoriumtoestande te bepaal sowel as deur 'n loodsstudie daarna in die Joe Slovo informele nedersetting in Kaapstad.

Honderde duisende inwoners in die informele nedersetting is aangewese op paraffien om aan hul daaglikse energiebenodighede te voldoen en ly onder traumatiese brande, kindervergiftigings en die gifgasse afgegee deur die brand van fossielbrandstof in 'n geslote, beknopte omgewing. Hoewel hierdie werk die redes vir die paraffien-keuse intensief ondersoek – spesifiek binne die grense van die Wes-Kaap – lewer dit ook kommentaar op ander energiedraers wat dwarsdeur die land gebruik word. Die doel van sowel die loods- as die laboratoriumstudies was om die empiriese bewys te voorsien – gerugsteun deur sosiale kommentaar, grotendeels geregverdig deur die beskikbare literatuur oor die noodsaaklikheid vir die voorsiening van meer volhoubare energiekeuses – spesifiek vir behoeftiges.

Krities tot die oogmerk van die uitvloeiels van dié dokument was om die vlakke van volhoubaarheid van etanol-jelbrandstof en sy potensiële toekomstige gebruik te bepaal. Hierdie evaluering ondersoek die ekonomiese, sosiale en omgewingsparameters van die produk onder huidige toestande. Vervolgens wil dit vasstel watter toestande en kriteria benodig word vir sy toekomstige verspreiding. Hoewel die bevinding nie 'n besliste antwoord op die toekoms van jelbrandstof in Suid-Afrikaanse omgewings volledig deur 'n enkele werk soos hierdie kon bepaal nie, word gehoop dat hierdie tesis en ander beperkte materiaal oor die onderwerp as inspirasie tot toekomstige navorsing in hierdie veld sal dien.

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I cannot begin to thank adequately all those that have played a role in the complex work undertaken without all of whom this document would not have been possible.

Each of the people and bodies mentioned here are done so by way of convention in a chronological order of their involvement and by no ways reflect the degree to which their participation has contributed towards this work. Suffice to say, that without the role of each and every one of the actors listed below, the show would not have gone on.

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Lastly and to break with the chronological convention mentioned above I wish to make a special mention and dedicate this thesis to my wife, Zaida. You have stood by me through an academic voyage that has spanned seven years, making vast sacrifices while showing a massive commitment through your unselfish love that has culminated in this work. Without you none of this would have been possible.

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**List of Abbreviations**

<b>ANC</b>	<b>African National Congress.</b>
<b>CO2</b>	<b>Carbon Dioxide</b>
<b>DME</b>	<b>Department of Minerals and Energy</b>
<b>DSM</b>	<b>Demand Side Management</b>
<b>ESKOM</b>	<b>Electricity Supply Commission</b>
<b>FBE</b>	<b>Free Basic Electricity</b>
<b>GWh</b>	<b>Gigawatt hour</b>
<b>IPCC</b>	<b>International Panel for Climate Change</b>
<b>IUCN</b>	<b>International Union for Conservation of Nature and Natural Resources</b>
<b>Kcal</b>	<b>Kilocalories</b>
<b>LCA</b>	<b>Life Cycle Analysis</b>
<b>MtCO2</b>	<b>Megatons Carbon Dioxide</b>
<b>NER</b>	<b>National Energy Regulator</b>
<b>PAR</b>	<b>Participatory Action Research.</b>
<b>PASASA</b>	<b>Paraffin Safety Association</b>
<b>PPM</b>	<b>Parts per Million</b>
<b>RDP</b>	<b>Reconstruction and Development Programme</b>
<b>SAPIA</b>	<b>South African Petroleum Association.</b>
<b>SARPN</b>	<b>South African Regional Poverty Network</b>
<b>UNDP</b>	<b>United Nations Development Programme</b>
<b>WCED</b>	<b>World Commission on Environment and Development</b>

## CHAPTER 1: Introduction

### 1.1 Background: energy as a critical issue in South Africa

Ever since our ancestors stumbled upon the potential usefulness of fire our species has attempted to find ways in which to harness and utilise its energy. Some archaeologists (Dawkins, 2004) believe that fire was in fact the first ideological possession nurtured by proto humans. Brain (1981) has shown that the earliest evidence of the manipulation of fire by hominins took place some 1.8 million years ago when *Australopithecus Africanus* used it in the area of what today forms the Swartkraans caves in South Africa. Dawkins (2004) believes that fire formed the basis of many early relationships as it was shared amongst different communities. In a more modern context although access to energy derived from various sources is according to the United Nations a basic human right (United Nations Committee on Economic, Social and Cultural rights, 1991), many are deprived of or have to pay dearly for its luxury as a heating and cooking source. Although there is no specified right to energy within the South African constitution like there is to water (Constitution of South Africa, 1996) the South African constitutional court in the landmark Grootboom case recognised the implied right to energy through the state's obligation to house its population (Government of the Republic of South Africa v Grootboom, 2000). Despite these proclamations on a global and regional level it is the poor who most often are denied or exploited in their attempt to exercise this right.

Rapid urbanization trends within developing countries have given rise to burgeoning unplanned housing settlements. According to census data from 2001, 7.7 million South African inhabitants were housed in informal settlements (Statistics South Africa, 2001)<sup>1</sup>. South Africa's Gini coefficient<sup>2</sup> ranks amongst the highest in the world, having risen from 0.68 in 1991 to 0.77 in 2001. As noted by the South African Regional Poverty Network (SARPN, 1994), the disparity between rich and poor South Africans could not be more

---

<sup>1</sup> Statistics South Africa provided these figures according to the census survey of 2001 but is seen by many to be highly inaccurate. . Barry and Ruther (2005) highlight how complex gaining accurate survey data from informal settlements within South Africa can be.

<sup>2</sup> The Gini Coefficient as described by Deaton (1997) is a variable measure through which macroeconomic data can be analysed. In the form presented above, calculated from the census data the closer to 1 the fraction represented, the greater the disparity between rich and poor.

stark. As well-heeled suburbanites spend some 1% of their monthly income on electricity, figures from informal settlements have shown that as much as 35% of an average monthly income of around R750 is spent on energy. Eberhard and Van Horen (1995) show that there is an almost direct correlation between income and energy expenditure, particularly amongst the poor. A lack of infrastructure in these shack environments limits the resources available to many residents who are often forced to use unsafe and unhealthy energy sources for cooking and heating.

With what now seems irrefutable evidence, global warming is taking place at unprecedented rates with temperature rises the most dramatic in 800 000 years, largely as a result of fossil fuel burning and the resultant CO<sub>2</sub> emissions (Wolf, 2006). Initiatives towards cleaner, safer fuel technologies could therefore not be more pressing. While there is an urgent need for large infrastructure-based electricity generators to look toward alternative, more environmentally-friendly power sources, there is certainly a major contribution that could be made by local, often poor, fossil fuel-burning communities. The move to a more sustainable energy and environmental future encompasses more than just a focus on electricity, and hence requires more diverse and decentralised methods of energy demand reduction and fuel switching such as moving households from paraffin to bioethanol gelfuel.

## **1.2 Aim of the study**

The study aims to examine whether the use of an ethanol based gel fuel within the Western Cape informal settlements is more sustainable than other energy alternatives. It sets out to test the following hypothesis, which consists of three assumptions:

- a) that the existing energy sources most freely available to people in informal settlement all have discernable drawbacks, which may be financial, practical, social, environmental or health-related;
- b) that an alternative to fossil fuel could be acceptable, affordable, less hazardous and beneficial to informal settlement communities; and
- c) that an Ethanol-based gel fuel could go some way to providing just such an alternative.

A combination of methods has been used to test the assumptions above through the course of this study (see Section 3).

### 1.3 Objectives of the study

The specific objectives of this study are as follows:

1. To investigate the various energy sources available to informal settlement communities in urban South Africa and consider their social, economic and environmental advantages and disadvantages;
2. To examine and compare specific criteria of different energy sources, thus providing a profile of how and why particular carriers are used in particular scenarios;
3. To select and consult with a specific sample community in an informal settlement, within which to conduct a pilot study to test a possible alternative to fossil fuel-based energy sources;
4. To establish the viability of an Ethanol-based gel fuel as a practical alternative energy source for cooking by conducting a supervised 'cook-off', based on typical cooking time and requirements of the sample group;
5. To introduce an Ethanol-based gel fuel, under monitored conditions, as an alternative to fossil fuel-based energy sources, in a sample population within a South African informal settlement;
6. To monitor and analyse the use patterns of Ethanol-based gel fuel viz à viz other energy sources amongst the sample group for a limited study period of six weeks;
7. To analyse the findings from the pilot study to establish the viability of ethanol-based gel as an alternative energy source for the specific informal settlement community in the Western Cape; and finally
8. To assess the potential impact, implications and sustainability of promoting ethanol-based gel fuel as an alternative energy source on a larger scale in South African informal settlements.

### 1.4 Chapter outline

The rest of the study is structured as follows:

- **Chapter two** comprises a literature review on the main themes relating to the research question i.e, whether gel fuel can play a role as a sustainable alternative to fossil fuels use within informal settlements. The key themes explored in this chapter

include the measurement of sustainability, fossil fuels and peak oil, South African informal settlements, a broad overview of housing and energy policy in South Africa, energy choices of the poor, and ethanol gel fuel.

- **Chapter three** presents the research design and introduces the specific suite of tools that have been used to investigate the research hypothesis. It explains the various data collection techniques that were employed to gather information about energy use patterns in the sample community, and includes a description of the selected community itself. The survey and sample parameters are laid out and the chapter is concluded with an explanation of the limitations and shortcomings of the data collected.
- **Chapter four** gives a detailed overview of the findings flowing from a pilot study that had been conducted. It considers the data derived from the testing of ethanol-based gel fuel and its viability as an energy source for cooking in informal settlements. It also closely examines the quantitative and qualitative information on the use of various energy sources, including ethanol-based gel fuel, within a sample group during the study period.
- **Chapter five** discusses the findings of gathered data from a broader perspective. It compares financial and environmental health implications of various energy sources used within informal settlements and draws conclusions as to the potential for using ethanol-based gel fuel on a larger scale in South Africa. It also provides a sustainability assessment of the energy sources, with specific reference to possible ways of curtailing environmental damage.
- **Chapter six** concludes the study by drawing together the results and making a number of recommendations.

## CHAPTER 2: Literature review

This chapter sets the background against which the research question was formed and provides a platform for the examination of the various concepts explored therein.

Due to the transdisciplinary approach of the research undertaken, it was necessary to consult a wide array of published and unpublished material. The literature review encompasses the following areas:

- The concept of sustainability and its appropriateness as a measuring tool;
- The global ramifications of fossil fuel use and peak oil;
- Urbanization, apartheid and the consequent evolution of South African informal settlements;
- Housing and energy policy in South Africa;
- Fuel choices, financial constraints and consequences for the poor in the Western Cape's informal settlements; and
- Previous research conducted in the field of Ethanol gel fuel that helped to inform this study.

The table below provides an overview of the literature review by theme which corresponds to section headings according to a descending temporal scale.

THEME	SCALE
<b>Sustainable development and measuring sustainability</b>	<b>General philosophy applied as a universal principal</b>
<b>Fossil Fuel Burning and Peak Oil</b>	<b>Global consequences of Fossil Fuel use and Global Economic implications as the world moves towards peak oil</b>
<b>South African Informal Settlements</b>	<b>Global phenomenon of Urbanisation, Population Growth and Poverty on a National Level</b>
<b>Government's obligation – Housing &amp; Energy Policy in South Africa</b>	<b>National and Regional Level</b>
<b>Energy Choice of the poor</b>	<b>Local Level</b>
<b>Ethanol Gel Fuel</b>	<b>Product Specific</b>

Table 1.  
Literature review

## 2.1 Measuring sustainability

The title to the opening section of this literature review may to the deeply philosophical thinker seem oxymoronic. The question may be posed, that how if sustainability in the strict sense of the word goes on ad infinitum can it be measured. The mere fact that something is sustainable may to some, refer to its capability of infiniteness and be therefore by definition, immeasurable. The term here is borrowed directly from a work by Bell and Morse (2003) who provide a synopsis of how and why sustainability indicators used to measure sustainability are critical to the discipline of sustainable development. This does not necessarily mean that we need to adopt a strictly reductionist approach to appreciate the necessity to measure sustainability or the methods used. Mebratu (1998) so eloquently reminds us that there are not only several forms of sustainability but that they are contextually bound by their specific origin. This may be institutional, ideological or academic. (As no writing on the subject would be complete without a definition of sustainable development and the concept of sustainability as referred to here, one is provided in table 2 below.

### **Sustainable Development**

The idea had been adopted from the serious concerns during the 1970's that patterns of production and consumption were jeopardising the planet's ability to maintain its natural environmental equilibrium. Meadows et al (1972) in their report to the club of Rome, *The Limits to Growth*, concluded that,

*"if the present growth trends in world population, pollution, food production and resource depletion continue unchanged, the limits to growth on the planet will be reached within the next one hundred years"*.

The concept had its initial roots in the area of environmental conservation. Sustainable Development used as an official term was seen in the literature for the first time in the *World Conservation Strategy* in 1980 (IUCN, 1980). The World Commission on Environment and Development (WCED, 1987) report, (commonly referred to as the Brundtland Report named after its Norwegian chairwoman) popularised the term, and provided the original definition:

*"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*

Pearce, Markandaya and Barbier in their book, *Blueprint for a Green Economy* provide, "a gallery of definitions" (1989, appendix) to sustainable development. Despite the many definitions used to describe the concept across several disciplines the basic notion of sustainable development remains embedded in its earliest underpinnings.

Table 2  
Sustainable Development Definition

Dresner's (2002) *Principles of Sustainability* highlights the need for measures and points out that the very notion of achieving sustainability implies that it can be measured. For the purpose of these measurements many different sets of indicators have been suggested in the literature. Whilst some, such as Brugman (1997) may be sceptical of indicators of sustainability and others such as Lomborg (2001) denigrate what indicators represent, they remain critical as measures describing the condition of our planet. Indicators used by Brown, Flavin and French (2001) formed the basis of their *WorldWatch Report*, a seminal commentary that described the state of the world through a snapshot moment in time. The document forms part of an important and popular discourse in the area of Sustainable Development and presents its readers with a clinical appreciation for why indicators are vital as descriptive and analytical tools. Indicators provide the benchmark against which current and future developmental objectives can be measured.

Although many varying conceptual frameworks of sustainable development have been developed including, The Hanover Principle (2000), The Natural Step system conditions (Robèrt, 2002) Herman Daly Rules (Daly, 2005), The Bellagio Principles as described so comprehensively by Hardi and Zdan (1997) and the Earth Charter (2006) to mention but a few, there are a set of core themes that do exist. The key themes in the literature seem to relate back to the original idea posited by Goodland and Daly (1996), where the interactions between the economic, ecological and social development are all paid due concern within the developmental paradigm. It is these three criteria that form the basis for the findings in chapters four and five. These themes all attest to the importance of an awareness of the integration of indicators so succinctly explained by Bell and Morse (2003).

Although authors see many additional elements of sustainable development, across varying disciplines as critical to a deeper understanding of the concept, many provide an underpinning of this study rather than being directly attached to the research undertaken. The importance of ecophilosophy described by Davis (1989), *The Earthscan Reader in Sustainable Cities* (Satterthwaite, 1999) and the influential writings on ecofeminism by Merchant (1994 & 2005) highlighting the importance of biodiversity and ecology for example, have all played a subliminal role in the creation of this particular work. With an understanding of the general underpinnings of sustainable development and its relevance to this work a more focussed approach has been used in the remainder of the literature review.

## 2.2 Fossil fuels and peak oil

It may seem out of place that an entire section of a locally based research devote such a considerable concentration to the global phenomena of the consequences of fossil fuel use and ramifications of peak oil. Following our previous theme of sustainable development and if as suggested by Norberg-Hodge (2000) our local actions have global consequences, then by definition, our local actions can prevent global consequences. Logically Meadows et al (1972) warn that, as we are not fully aware of environmental thresholds or the consequences of overstepping them that we should err rather on the side of conservatism.

Robert Watson (Roberts 2004:139), the previous head of the Intergovernmental Panel for Climate Change, (IPCC) maintained that, "*stabilising atmospheric CO<sub>2</sub> emissions now at 550 parts per million (ppm), may slow global warming down but it will not halt its march upwards before 2030*". While the literature includes those sceptical of the potential consequences of global warming related to the burning of fossil fuels, such as Lomborg (2001), certain facts can no longer be denied. Groundbreaking work performed in Antarctica by Eric Wolf (2006) of the British Antarctic Survey shows that there is a higher degree of CO<sub>2</sub> in the atmosphere than has existed in 800 000 years. Wolf points out that whenever high CO<sub>2</sub> levels existed in the past, radical climate shifts took place. Seminal writings by Vitousek (1992 & 1994) on the carbon cycle and the effects of pushing beyond the limitations within the cycle explain that climate change could result in mass extinction events similar to those witnessed throughout earth's history.

The recognition of anthropogenic CO<sub>2</sub> in the atmosphere and resultant global warming are becoming more evident even within the mainstream media (BBC, 2006). Previously the preserve of hard-core atmospheric scientists and climatologists, environmental activists from a vast array of disciplines have shown an interest in the phenomena of fossil fuel burning and resultant consequences for the planet.

The concept of 'peak oil' was first described by Hubert, (Heinberg 2003) a Shell oil geophysicist. Hubert's peak is modelled on a parabolic curve, at the top of which oil begins to decline. As a layman's explanation, Heinberg (2003) classifies peak oil as the point at which the oil in the ground can no longer satisfy global demand. At the reservoir level it is important to note that peaking occurs after half of the recoverable oil has been drilled. The result of this is that fuel prices will increase exponentially for two reasons. Firstly, oil companies are likely to maximise what profits can still be squeezed out of fuel-dependent economies while they can, and secondly, the deeper the oil the more costly it is to drill. Paul Roberts in his work, *The end of oil* (Roberts, 2004), goes even further than Heinberg by indicating in his research that we have already past the point of no return. As a reporter he believes that oil companies are covering up the fact that wells predominantly located in the Middle East can no longer meet global demands.

Critical to the motivation behind this study has been the examination of possible factors contributing to the slowing down of global warming. Peak oil ironically within itself may in fact provide a partial natural solution in that alternatives to crude and gas will have to be sought not purely as a result of environmental pressures but because they are no longer economically viable to retrieve. In the interim as Rutledge (2006) observes, prices will however continue to escalate with increasing demand for the diminishing resources, placing even greater financial burden on those reliant on their use. As paraffin is an oil derivative and a chief energy source within the study area, it is seen as critical as pointed out within the aims and objectives of this work to seek solutions that will mitigate these effects both now and into the future.

### **2.3 South African informal settlements**

The United Nations Urban Settlement Report (2003) describes the global trend within developing nations of the rapid growth of urbanized poor settlements. Seminal literature by Satterthwaite et al (1999) provides insight into the root causes of how and why informal settlements were established. Described in the literature as "slums", "shanty towns", "faveles" and "bidonvilles" (Haggett, 1975: 406) these environments are often mistakenly assumed to be similar in nature irrespective of location. Often the socio-political and historical events that led to the creation of specific informal settlements are critical to an

understanding of their unique characteristics. Anzorena (1994:17) however does point out that the main overriding determinant for the construction of informal settlements is the fact that impoverished communities have no access to the means to build, “conventional housing”.

Maharaj (1994) shows how acts of parliament helped to shape the existence and nature of South African informal settlements. The Group Areas Act (Republic of South Africa, No 41 of 1950) provided the apartheid government with a legislative tool to control land ownership and promote racial segregation. Drummond and Parnell (1991) provide an overview of how black South Africans were encouraged to move into homelands that were overcrowded, underdeveloped and offered ownership of land that was agriculturally unproductive. Drummond and Parnell (1991) further examine how the Bantu Self Government Act of 1959 (Republic of South Africa, No 46 of 1959) promoted separate development within the homelands. The Pass Law of 1950 (Population Registration Act, Republic of South Africa, No 30 of 1950) was abolished in 1985 and this encouraged high rates of migration from rural to urban areas, as a large economically depressed population went in search of work. The Prevention of Illegal Squatting Act of 1951 (Republic of South Africa, No 41 of 1951) was replaced by The Prevention of Illegal Evictions and Unlawful Occupation of Land Act (Republic of South Africa, No 19 of 1998) in 1998. The new law made it illegal for residents to be forcefully evicted without a court order.

The Housing White Paper of 1994 (Republic of South Africa, 1994) revealed that 7.7 million people in South Africa resided in informal settlements. The Human Sciences Research Council (Cross, 2006) shows that the growth rate of informal settlements has increased dramatically since 1994 as a consequence of apartheid ending and the right to freedom of movement. It must be noted that accurate demographics are difficult to obtain within informal settlements due to their dynamic nature.

## 2.4 Housing and energy policy in South Africa

In the current South African context housing and energy policy are inextricably linked. As we have already noted the Grootboom case heard in the constitutional court in 2001 brought together so succinctly the fact that adequate housing and access to basic services including Electricity were by proclamation, basic human rights (Government of the Republic of South Africa v Grootboom, 2000). Despite a general reluctance to installing fixed infrastructure into informal settlements the National Energy Regulator (NER, 2001) showed that 84 % of urban households had access to electricity in 2000. This was up, as noted by Praetorius and Bleyl (2006) from 36% in 1991. The then minister of Minerals and Energy Phumzile Mlambo-Ngcuka, committed in 2004 to provide universal access to electricity by 2012 (Mlambo-Ngcuka, 2004). Despite these efforts to provide electrification through the national utility ESKOM (which has a virtual monopoly in the sector), low-income houses can afford neither the connection fee nor the price of electricity (Mehlwana, 1999). The Department of Minerals and Energy (DME), strongly encouraged by President Mbeki (DME 2005, Mbeki 2004) have recently begun implementing the free basic electricity (FBE) scheme. FBE will offer 50kWh per month to most households throughout the country that have access to electricity. Howells et al, (2006) point out however that ESKOM is already struggling to keep up with the current demand and FBE initiatives will at expected production rates affect the “reserve margin”<sup>3</sup>.

It is critical to note that ESKOM presently relies on coal-fired power stations, a single nuclear facility and hydroelectric power to provide the bulk of current demand. Spalding-Fecher and Matibe (2003) explain through a series of complex measurements that electricity may have no significant externalities at a household level but that air pollution and acidification at a national, regional and global level from coal burning power stations could be significant. Although the ANC claims much credit for its commitment to providing electricity to marginalized communities which was initially proposed through the Reconstruction and Development Programme (RDP), (ANC, 1994) an assessment of the externalities and ramifications of connecting these households to the grid both financially and environmentally at this time were never properly conducted.

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<sup>3</sup> The “Reserve Margin” is a 15% buffer zone that needs to be maintained to assure the stability of delivery if a plant or line is taken out of service. See Howells et al (2006)

Nuclear energy is believed by many to be a cleaner option than coal. The problem with this technology is the difficulty of disposing of the radioactive waste. Debates around a range of new pebble bed facilities and the incorporation of renewable energy production technology are on going. Currently wind generation pilot studies are underway in Darling (Benton, 2006) and Klipheuwel, both north of Cape Town. South Africa's renewable energy target as set in the National Renewable and Clean Energy White Paper (DME, 2002) is to generate 10 000GWh from wind, solar, biomass and small-scale hydro plants by 2013. All of these initiatives will no doubt have an impact into the future of energy related policy within the country.

## **2.5 Energy choices available to people living in poverty**

In his research on energy carriers amongst informal settlement dwellers in the Western Cape, Ross (1993:44) highlights how choice is inextricably linked to availability and cost and also has huge social ramifications. He warns that, "transition models" created by developers are often based on modernist linear progression models that predict increased development. Ayers, Turton and Caston (2006) who link the role of energy to economic development also warn that the trend amongst most economists is to see that link along parallel trajectories. The trend would predict that growth and "more sophisticated" energy options move in conjunction with attempts to move out of poverty. Irrespective of the criticisms levelled against transition models within the literature by Ross (1993), and Annecke (1993), amongst others, these assumptions still tend to underpin most policy and development initiatives in South Africa. The underlying theme in the RDP with regards to energy clearly illustrates this point. Amalya Reddy (2000:41) in a world energy assessment offers a view of poverty and related energy and believes that the choice of the poor is dramatically curtailed by circumstance:

*"what human beings really want is not oil or coal or even gasoline or electricity per se, but the services that those sources provide". She then points out that,*  
*"Because efficient devices tend to have higher first costs, the poor invariably end up with less efficient devices that consume more energy for a given level of service."*

In summary, due to unpredictability of circumstances, insecurity of tenure and irregular income patterns, most residents in informal urban environments use a mix of energy carriers. A more detailed research into the energy profile within informal settlements and the study area can be found in section 4.3.

## 2.6 Ethanol gel fuel

**In keeping with the conventions of the local trade vernacular, several colloquial terms are used to refer to Ethanol gel throughout this document. These include Ethanol gel fuel, Ethanol gel, Gel fuel, Biogel, Jelly and gel.**

Table 3  
Ethanol gel fuel definition

With recent growth in the popularity of Ethanol gel, several articles have appeared in the popular media (The Argus, 2006; Mail & Guardian, 2006 & SABC, 2005). The first serious initiative to research the product for use by the poor was conducted by Boris Utria who was responsible for setting up the Millennium gel fuel project in Southern Africa (Utria, 2004). The aim was to attempt to move households away from using wood fuels, as trees in the area were diminishing in number as well as giving off noxious emissions when burnt as charcoal for cooking. Sponsored by the World Bank (2004), this initiative was seen to be in line with attempts to advance towards the Millennium Development Goals<sup>4</sup>. Utria's documentation provided the platform from which other research was initiated. Williams (2002), a co-researcher and colleague, provided valuable data on the potential for ethanol use and development within Sub-Saharan Africa.

Tilimo and Kassa (2004) showed in consumer behaviour research conducted in several Southern African countries that gel fuel was acceptable within the household energy market. A brief paper by Byrd and Rode (2005) provide a snapshot view of a study conducted over two weeks in Khayelitsha. The motivation behind the study was largely as a result of professor Rode's investigation into child burns and poisoning through paraffin related

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<sup>4</sup> The reference to the Millennium Development Goals above is a general reference. A more detailed reference pertaining to their relevance with regard to energy specifically can be found in the Department for International Development document (2000).

accidents. As the head of surgery at Red Cross childrens hospital he had first hand knowledge of the consequences of these occurrences. Other work conducted by Le Roux (2004) specifically on ethanol gel fuel has been referred to in this and other literature but several authors query the authenticity of his some of his findings<sup>5</sup>. There is however merit in some of his work, particularly pertaining to some of the cost component data and for this reason it was deemed relevant as part of this literature review.

As can be noted from the brevity of this literature review specifically of ethanol gel fuel, not a lot has been written on the subject. This is particularly true of academic materials. Most available research papers deal with ethanol more generally. One study (Dawson, Bester and Austin, 2006) examines the viability of producing Ethanol specifically for gel fuel from different biomass feedstocks. The research has gone some way into investigating the financial ramifications and potential opportunities that exist within the gel fuel market and succeeds in marrying ethanol production with gel manufacture.

From the broad brush strokes of a definition of sustainable development to the focussed area of ethanol gel fuel the literature review has provided the platform on which the research and data collection and collation phases of this work rests.

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<sup>5</sup> The data regarding gel stove efficiency compared with paraffin stoves directly has been questioned in both the Byrd and Rode (2005) and the Dawson, Bester and Austin (2006) studies. As the body of knowledge regarding certain aspects of ethanol gel fuel study is in its infancy as many available references have been drawn on as possible.

## **CHAPTER 3: Research design and methodology**

This chapter provides a description of the techniques that were used to gather and analyse information during the course of the study. It includes an outline of the research design and an explanation of why the specific methodology was chosen to best answer the research question. It also explains the limitations experienced within the data gathering and analytical processes.

### **3.1 Research hypothesis**

The study sets out to examine whether the use of ethanol based gel fuel within Western Cape informal settlements is more sustainable than other energy alternatives.

### **3.2 Key concepts**

Many of the key concepts relating to the hypothesis have already been explored in the literature review. The following additional concepts pertain more specifically to the methodology rather than the subject matter of the study.

#### **3.2.1 Sustainability**

As explained earlier in section 2.1 the notions of Sustainability and concept of Sustainable Development have become virtual household terms. For the purposes of this research it was found necessary to use an evaluation tool that would adequately measure sets of variables that would inform the investigation. The specific definition and analytical tool used to measure sustainability were those first informed by Goodland and Daly (1996). The nexus of the definition is in the interlinking of the social, economic and environmental paradigms and used within the research process as a comparative tool of measure.

#### **3.2.2 Triangulation**

The term, borrowed from the practise of physical surveying techniques so as to establish a location by means of bearings (Beebe 2001) is most useful here. In a literal sense,

triangulation has been used as a plotting tool to investigate many complex phenomena, including sustainable development. Although Denzin and Lincoln (1994) warn that seeing triangulation as a validation tool can lead to a blurring of objectivity it is not used in isolation in this study to prescribe the research process. The triangulation metaphor is also used to provide what Flick (1992:194) refers to as a methodological tool that can add “breadth and depth” to data interpretation. In this sense, the integration of the various research design types explored below culminates in a single synthesis, which goes to the very core of testing the research hypothesis.

### 3.3 Research design

A variety of research methods and design types as described by Mouton (2001), have been incorporated into the study, in order to provide a conduit for data accumulation, capturing and processing. The methods stand alone, each to perform its singular specific function, and in instances are integrated as part of the triangulation process. The discussion below briefly leads the reader through the research phases and the reasons for their inclusion as part of the methodological process. Figure 1 below provides a graphic synopsis of the methodologies contained in the research process.

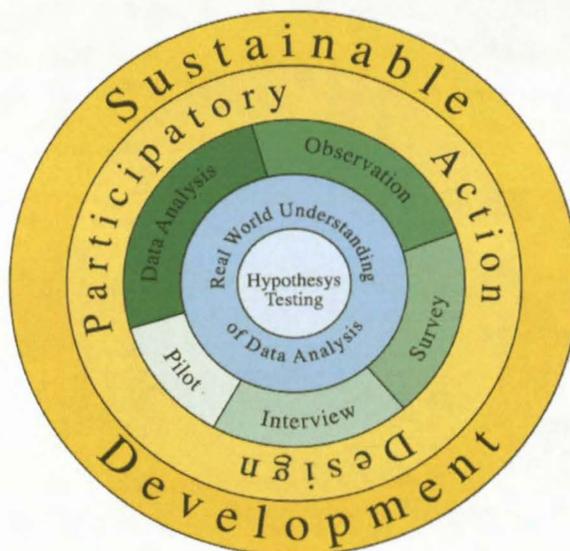


Figure 1.

Graphic representation of the methodological design

The diagram in Figure 1 indicates the design process and the corresponding cognitive levels that were employed to reach the hypothesis testing stage of the research.

### **3.3.1 A participatory orientation**

The research design was first and foremost influenced by many of the principles of Participatory Action Research (PAR). One of the chief criteria for PAR is to develop an emic perspective so that relationships between researcher and participants are encouraged. PAR would both inform the direction and pace of the study as well as create cohesion between the other design elements. As a large component of this study depended on a pilot study within an active community, it was necessary to establish from the outset what kind of relationships would guide the research process. The literature on PAR provided useful guidance as it emphasised a need to be aware of the power relations between researchers and participants. For example, in a fully participative research approach, this relationship could be described as “radically egalitarian” (Reason 1994:334). Elliott (1994) draws attention to the need to empower from within through the research process. With these ideas in mind, the general orientation of the research approach was conceptualised to make adequate space for consultation, design input and feedback from participants, and wherever possible, further opportunities for meaningful participation.

### **3.3.2 Selecting a sample community for the study**

To examine the impact of gel fuel in a specific environment within a South African context, the informal settlement of Joe Slovo was chosen. Situated on the N2 highway 10km south-east of the central business district (CBD) of Cape Town, Joe Slovo developed primarily after 1994, amidst a new democratic South African political climate. Those settling in Joe Slovo came mostly from the rapidly expanding and overcrowded township of nearby Langa, but also included newcomers from the Eastern Cape. Informal dwellings (in Joe Slovo), described by locals generically as shacks, increased from 3429 in 1996 to 5547 in 2001 (Statistics SA, 2001). Constructed largely of scrap wood and corrugated iron, the houses are susceptible to the harsh weather conditions of the Western Cape. Infamously described as

the Cape of Storms by Bartholomew Diaz, (City of Cape Town, 2006) residents here suffer gale force South Easterly winds in summer and driving rains in winter.

Risk from fire is a serious hazard, with Joe Slovo recording some of the highest and most devastating fire damage statistics in the country over a 10-year period (Murambadoro 2005). The United Nations Human Settlements Programme (2003) notes that housing density and house structure can increase the severity of fire. Murambadoro (2005) observes through measurements taken that the physical gap between some dwellings in Joe Slovo is only 29 cm, as residents attempt to maximise the use of available space. The situation exists, despite constant pleas from fire officials who highlight the fact that not only is there a greater risk of one house setting another alight due to the close proximity of neighbours, but also that fire fighters cannot effectively move between houses to extinguish blazes.

Due to financial constraints of informal settlement dwellers in South Africa, choice of fuel for energy is often restricted to options that are affordable. Historically, the use of coal and paraffin, have tended to be the most popular cooking fuel have been made by government to change this trend through initiatives such as the Free Basic Electricity (FBE) scheme, announced by South African president Thabo Mbeki in 2004 (Mbeki, 2004). However, the 50kWh /month free electricity per household would only apply to those that were connected to the grid. A study conducted by Winkler, Alfstaad & Howells (2005) show that half of the nation's poor (defined as those in the bottom two quintiles) are not electrified, and hence the FBE is not useful to them.

Residents of Joe Slovo specifically are reliant on paraffin as a chief cooking and heating source with some 30, 000 litres being burnt there a month. Statistics provided by The Paraffin Safety Association of South Africa (PASASA) (Kruger, 2005) estimate that between 40000 and 80000 paraffin related fires annually claim approximately 3000 lives per annum. Truran (2004) goes on to explain how paraffin is also responsible for between 60000 and 80000 incidents of poisoning in South Africa per year. The poisonings tend to occur more frequently amongst children who mistakenly drink paraffin believing it to be water. Anecdotal evidence from the staff at the Red Cross Children's Hospital and from residents within the study area confirmed that paraffin ingestions occurred frequently within Joe Slovo. Conversations with the Poison Unit at Tygerberg Hospital (Muller, 2006) and The Red Cross Children's Hospital (Rode, 2006) revealed that no accurate and up to date

official statistics regarding paraffin related poisonings exist within the Western Cape. It was against this backdrop that Joe Slovo was specifically chosen as the most appropriate area for the research to take place. An informal introduction process that encouraged open communication took place at some of the participant's homes in Joe Slovo and was followed by a pilot study.

### **3.3.3 Research design workshop**

A pilot study was constructed so as to establish the future direction and construction of the research design. This was to be the first phase in the data collection process and would act as a conduit bringing researchers, facilitators and participants together. The chief purpose of this phase was for the participants to provide an insiders view of appropriate survey design. Following suggestions by Babbie and Mouton (2001) it was decided that for the participants experience to have any real meaning, researchers and participants would need to be involved from the initial design phase.

### **3.3.4 Comparative cook-off**

A comparative cook-off was then conducted, involving three female residents from Joe Slovo at the University of Cape Town's Chemical Engineering Department. Three meals, a breakfast, lunch and dinner chosen by the participants themselves, were cooked consecutively on a paraffin flame stove and a gel fuel stove. This exercise allowed for both quantitative data and rich qualitative information to be gathered on the basic viability of ethanol gel as an energy source for cooking by residents of the Joe Slovo informal settlement.

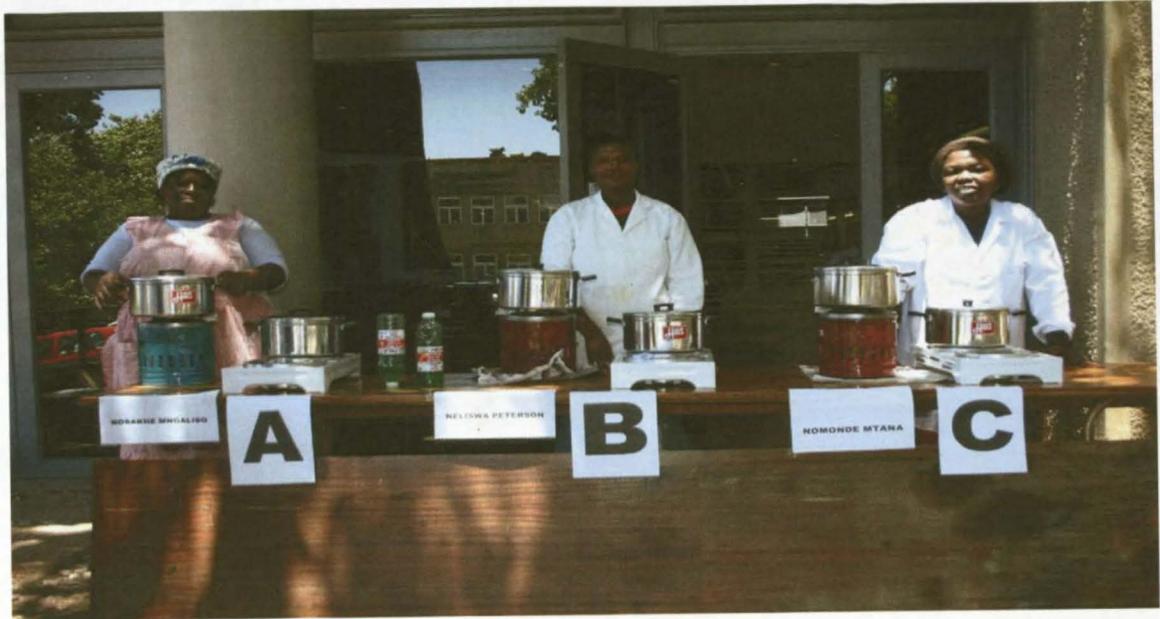


Figure 2.  
Cook-off at UCT

The primary aim of the lab experiment was to gather quantitative data from both paraffin and gel technologies, since it was deemed crucial for the gel fuel technology to be compared with other cooking technologies in use within the study area. The objective was to collect numeric primary data that would compliment the qualitative data also obtained during the experiment in order to better test the study hypothesis under the multi dimensional triangulation methodology described above.

Participants involved with the pilot were encouraged to perform many of the tests themselves and report the findings for recording by the two facilitators. The idea was to involve those who were part of the pilot survey to as great a degree as possible. There was also a belief that qualitative data gathered from less formal conversations and focus group interviews could only be enriched by as deep an understanding of the technology as possible. The qualitative data gained during the lab study provided the core information on which the larger survey was developed.

### 3.3.5 Survey of energy use patterns amongst selected Joe Slovo households

Based on the research design workshop and with the assistance of the facilitators and participants, a survey design was constructed. The survey was to provide specific information within the study area based on a series of questionnaires. A common problem often encountered, according to Stern (1979) with regard to research problems, is to establish what should be included and what should be left out. It was critical that the inductive reasoning process developed during the cook-off phase would be synthesised into the survey design.

As the survey was to form an important component of the study, it was critical that the design elements were what Sapsford (1999) refers to as valid and reliable. The contribution from the participants of the cook-off, their local knowledge of the sample population and the facilitators understanding of previous surveys conducted in the area all assisted to enrich the survey design.

#### Initial survey parameters

The survey was made possible with funding of a R50 000 grant from the Department of Environmental Affairs and Development Planning (DEADP). The conditions of the funding were that a detailed report be submitted to the department after the completion of the survey, in which the results would be outlined and explained.

The survey design consisted of 150 participants chosen from the area of Joe Slovo. The participants were chosen from zones 30 31 and 32 with the assistance of the responsible chair people. Participants were then to be given a two-plate gel stove and a five-litre bottle of ethanol gel and return every second week for a gel refill. The study was to run for 3 months during the Cape Town winter

Table 4  
Survey parameters

Unfortunately, on the first day of gel distribution, the container that was being used by the research team was mobbed in a violent attack by local youths, and some 50 stoves and 50 bottles of gel were stolen. Sticks and stones were thrown and despite many calls to the police who never arrived, nobody was seriously injured.

After much deliberation, advice from many sectors, and a guarantee of our safety from the local community, it was decided that the survey would continue. A revised sample size, down from the original 150 households to 100, was deemed to be adequate by a statistical expert. This meant however that there would not be an additional 1250 litres of gel. As we had lost two weeks whilst contemplating and then planning the future of the study, it was seen as an opportunity to distribute the gel weekly as opposed to fortnightly, as had originally been planned. This meant that although the sample size was smaller, the opportunity for interaction between the research team and participants was doubled. On the 24<sup>th</sup> May 2006, the survey continued in the Langa sports centre and ran without further incident until the end of July 2006.

### 3.3.6 Interviews

Interviews were conducted as formal question and answer sessions which took place in conjunction with the weekly gel distribution, as well as less formal focus group interviews. Typically interviews are face-to-face meetings where the participant answers questions posed by the researcher (Henerson, 1987).

#### **Language of communication**

For the purposes of this study, interpreters were necessary as the main language spoken within Joe Slovo is isiXhosa and the interviews were compiled in English. The facilitators who both spoke isiXhosa as their first language but used English in their professional and academic environments, doubled as translators for the interview process. While translation moves the researcher an additional step away from the sample, full faith placed in the integrity and experience of the facilitators alleviated much of this problem. Where English was possible and many participants spoke and understood sufficient English to answer many of the questions, it was used as the language of choice. It was interesting to note that as recipients became more familiar with the research team, and their confidence in the research process grew, so too did the openness of the discussion. Of the original three participants who took part in the cook-off process, two volunteered to assist with facilitation and translation.

Table 5.  
Language spoken in Joe Slovo Informal Settlement and translation

Many of the interviews took the form of focus group discussions. These focus group interviews were conducted to ascertain insights and perceptions of the local community.

According to Wilson (2005) focus group interviews are carefully planned discussions designed to gain the views of participants in a less formal manner. The interviews took place at the Langa Sports centre, and twice in people's homes within Joe Slovo. Debriefing sessions were held with the translators so that there was complete clarity on the most vital points under discussion. These sessions provided rich qualitative data and allowed for the ongoing adjustment of the more formal questionnaire (see Annexure 1) to better suit the aims of the study and its links to the sample group. These sessions also allowed for sharing less formal information that provided deep and interesting insights into the lifestyles of all who participated. Ethnographically, Geertz (1973) referred to this process as deep play and thick description. It was designed to allow the researcher and respondent to gain a deeper confidence and trust in one another. A further consequence of these meetings was that it allowed for direct observation of the cooking process (which was always encouraged during these visits) to be monitored and documented.

### **3.3.7 Observation**

The focus group interviews and occasional visits to the homes of the participants allowed for first hand observation to take place. Babbie and Mouton (2001) highlight the potential value that can be derived from simplistic observation within the research process. Field notes, photographs and taped conversations provided a valuable record that enhanced the data capture methodology, providing deeper insights of the sample population in a less structured environment.

### **3.3.8 Data analysis techniques/approaches**

With the complex mix of data collection methods used, it is all the more imperative to explain the data analysis techniques employed. To avoid confusion it is worth noting that the triangulation process already explained in the context of this document is a tool used to synthesize data once analysed. The analysis process followed what Tashakkori and Teddlie (1998) describe as a mixed methodological approach. In a broad sense, it involves the enjoining of qualitative and quantitative paradigms in a practical and logical manner.

On a micro-scale, the co-joining and cross-tabulation of the variables that allowed for the measurements addressed by the hypothesis would not have been possible without this mixed

methodological approach. The interrelationship of these variables allowed for a cross-over between the scientific and more socially-based indicators. This principle not only enriched the results achieved, but also worked in conjunction with the underlying theme of sustainability as described above.

A critical part of the analysis conducted for this research involved the study of secondary sources. Although much time and effort went into the compiling and collating of the empirical data, the study would not have been complete without referring to the secondary data on the subject. Hakim (1982:1) refers to secondary data as

*“... any further analysis of an existing data set which presents interpretations, conclusions or knowledge additional to or different from those presented in the first report in the inquiry as a whole and its main results.”*

The secondary data was incorporated into the research as complementary to the primary analysis and plugged into the existing analytic framework. Many of the sources for this data were derived from the previous research that was highlighted in the literature review.

### **3.4 Limitations and shortcomings of the research process**

The specific chosen methodologies that were used to conduct the research were widely varied so as to attempt to collect as wide an array of data as possible. The approach, whilst providing some interesting insights had the effect of not concentrating specifically on any single aspect of the study but rather presents a stereoscopic view of energy use and the potential for introduction of a new product into informal settlements. Some readers may well be justified in their criticism of the approach adopted as being vague and unscientific but the initial and main aim was to establish the potential sustainability of gel fuel as an alternative to fossil fuel use within informal settlements.

The initial incident at the outset of the survey may well have had an influence on the relationship between the research team and the participants. It was not part of the mandate of this study to establish how or to what degree these actions had an influence on the research findings. Anecdotal evidence showed that the incident seemed ironically to bring many people closer together, after sharing in what was seen as a frightening experience. It

was also never established what influence this event had on the image of the product. Richard Branson (2005) highlights the fact that every appearance in the life cycle of a product will subliminally affect those associated with it. This is after all the core principal behind advertising. Whether the influence was positive or negative on a particular participant, a bias was definitely realised. A further bias that was starkly obvious is that a comparison was being undertaken between the fuel carrier of choice, which was paid for by participants themselves, and the free weekly gel.

A dilemma that was pondered at length was that only a small group of 150 people were to initially form the sample for the study. The fact that the members of the sample population were chosen by political appointees (the Zone chairpersons) may also have had an influence on both who were included and the manner in which responses to questions may have been answered. As noted later in this study, those who participated in the sample group accrued some financial benefit in that the money they saved on purchasing energy resources for cooking could be spent elsewhere. Resentment was noted amongst some residents in the area as a result of not being part of the study, and comments directed at the research team showed their animosity to the process.



Figure 3.

Facilitation and Gel distribution at Langa Sports Complex

Almost a third of the sample group was lost towards the end of the study period, as an entire zone of Joe Slovo residents were moved to Delft. This move meant that they would not be able to participate in a further study planned to establish a distribution network once the research was completed. It was never the intention to just provide a free product, observe the population, collect and analyse data and leave. In the spirit of true sustainability, it was deemed critical that an ongoing employment opportunity be created from the study and that gel be made available after the study. The Delft residents were denied this opportunity.

A lack of local knowledge, the necessity for translation and the need to conduct research under sometimes uncertain conditions contributed to some ambiguities in the research process. Given the desire for the study to take place in Joe Slovo specifically, these compromises seemed a small price to pay.

## **Chapter 4: Results of the comparative cook-off and sample group research**

This chapter gives an overview of results of the data collection phase. It first considers the outcomes of the comparative cook-off process, which was used to establish a scientific base-line for using Ethanol-based gel as a fuel for cooking. It then provides a summary of the findings emerging from the research conducted amongst a sample group of residents of the Joe Slovo informal settlement, both at the beginning and end of the gel distribution period. An examination of energy carrier choice within Joe Slovo was seen as critical; this was first established and then segregated by product. This chapter sheds light on:

- the relative efficiency of ethanol gel and paraffin as energy sources for cooking;
- the perceptions of various energy sources amongst the sample group; and
- the actual energy use patterns of the sample group during the study period.

The research findings would then be broken down through a comparative analysis establishing the efficiency, affordability, social acceptability and most pertinent environmental indicators of Ethanol gel fuel compared with other major utilities.

### **4.1 Findings of the comparative cook-off**

An essential dimension of the triangulation process lay in the scientific analysis performed on the ethanol gel fuel. The cook-off using a paraffin wick or flame stove and a gel stove provided an opportunity to compare the two stoves directly. As paraffin stoves tend to be the chief cooking and water heating mechanisms within Joe Slovo, this direct comparison between gel and paraffin seemed essential. The data from this experiment was then combined with research conducted by other authors to provide a full overview of relative fuel efficiency.

Over and above the safety aspects of an energy carrier, one of the most important criteria is efficiency. There tends to be much controversy amongst stove and energy researchers as to

how to measure efficiency and what criteria should be used.<sup>6</sup> This research follows a traditional understanding of efficiency where directly comparable measurements of cooking time and fuel use of competing energy sources are evaluated. The cook-off showed that two meals cooked simultaneously on an ethanol gel and a paraffin stove had differing results in cooking time, but produced significantly different results in fuel use over time. The table below presents data from the cook-off. It illustrates that the longer the cooking period, the less gel was consumed relative to time. Conversely when gel and paraffin were used simultaneously in water boiling tests, some 15% less paraffin was used than gel.

**Cooking comparison between paraffin and ethanol gel fuel**

	Breakfast		Lunch		Supper	
	Time	Fuel use	Time	Fuel use	Time	Fuel use
Paraffin	18:50	80ML	1:20:00	350ML	3:15:00	800ML
Gel	21:30	100 ML	1:40:00	280ML	3:00:00	500ML

Table 6

It would appear that the shorter the cooking period, the less paraffin one would require when compared to gel. Conversely the longer the cooking time required to complete the meal, the less the gel needed, when compared with paraffin. It has been widely speculated that an improvement in gel-stove technology would increase efficiency even further.

Fuel composition seems to vary from manufacturer to manufacturer, in the case of both gel and paraffin. It was reported widely by the sample population, and the cook-off participants, those fluctuations in the consistency of paraffin quality were common. The paraffin used for the comparative testing was purchased from a local retailer and determined by the chefs of being of a superior quality to that which was purchased in the townships. According to a conversation with Colin McClelland (2006) of SAPIA the consistency in paraffin quality was caused largely by the storage facilities in which it was kept. This was confirmed by the participants. A lot of fuel became contaminated by the receptacle in which it was stored. The quality of the paraffin apparently had differing levels of efficiency, but this variable was not tested as part of this study.

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<sup>6</sup> For the purposes of this research, the debate was monitored through a stove mailing list used by many professionals in the industry. See [stoves@listserv.repp.org](mailto:stoves@listserv.repp.org).

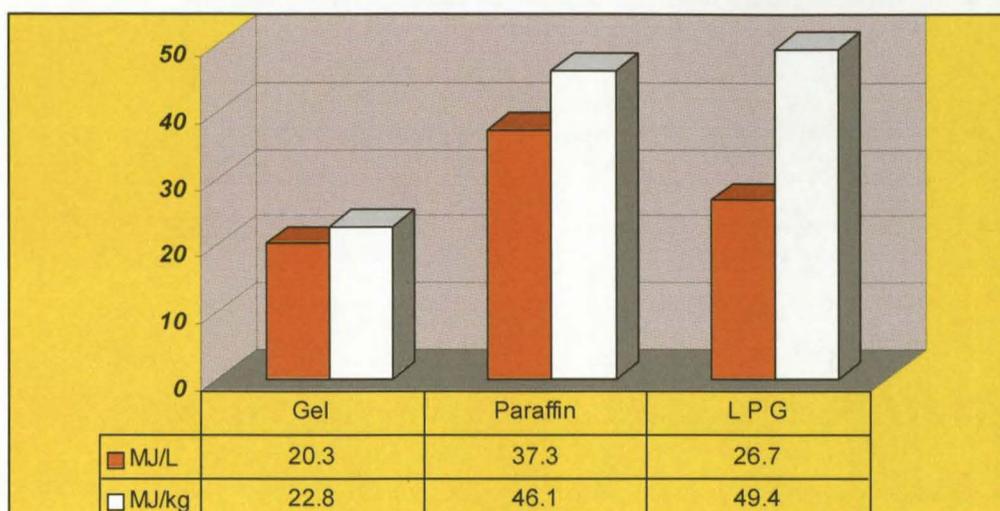
**Mass/volume by energy output: fuel comparison**

Figure 4

## Fuel comparison

A comparative analysis of efficiency calculated on actual energy outputs have been calculated independently by the Biomass Technology Group (BTG, 2001), Utria, (2004), and Le Roux (2004). From this data, it was possible to compile the table above. The figures are provided in MJ/kg and MJ/L. The reason for providing both comparative measures is because of the relative difference in LPG mass and potential energy output. Both of these measures are used in the literature. Just from the above table, it is clear how the use of a specific measure may lead to different interpretations and conclusions. Ethanol gel fuel contains varying degrees of water, which affects its density, and this would naturally affect the resultant energy efficiency when burnt. Ethanol quality and the quantity and quality of the gelling agent used would have an effect on the energy output of the gel. Dawson, Bester and Austin (2006) point out that standardization could help rectify this problem, but that standardization should not compromise safety or dramatically influence manufacturing costs.

#### **4.2 Findings regarding the perception of fuel sources amongst the sample group**

The literature review summarised earlier highlighted how energy choice amongst the poor is determined by availability and cost. Focus group interviews within Joe Slovo confirmed this theory. It was deemed important however to establish the choice preference within the sample group irrespective of these two parameters (cost and availability). As, for the

purposes of this study, the gel was being distributed free of charge and made available over the sample period, this would provide a null hypothesis against which the actual energy usage could be measured. Most of the research performed on energy choice, provides only an analysis of what utility is used and not what is desired. It must be noted that even though one specific energy carrier may be available and more desirable than another it may be less practical or too expensive either in infrastructure (such as in an electrical installation) or the related appliance and fuel costs.

It seemed only logical that as a new technology was being introduced, that its acceptability compared with other products purely on a cognitive level needed analysing. As part of the survey questionnaire in the second week, participants were asked to grade the various technologies irrespective of cost or availability. The five main energy carriers were included as options and participants were asked to rank the level of desirability of each on a scale from 1-10. The concept was loosely based on work conducted by Eberhard & Van Horen (1995) on household cooking fuels to ascertain the level of importance attached to different fuel choices. The research question was not dissimilar to marketing surveys conducted to determine a product's desirability in the market place. The graph below shows that electrification was the most desirable form of energy with a score of 96%, the biogel had an acceptability rating of 77%, paraffin 63%, LPG gas rated 43% while wood was not seen as very desirable.

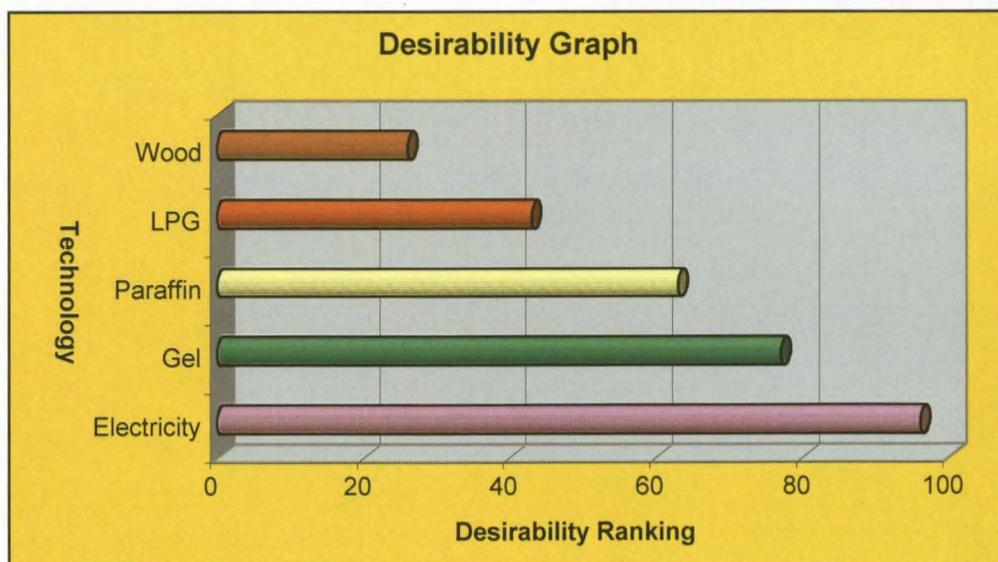


Figure 5  
Desirability Graph

Figure 5 above should not be confused with energy transition models as explained within the literature review but rather as an introductory analysis to the concept of fuel choice. There is a deep appreciation of the opinion that is posited by Eberhard and Van Horen (1995) that the energy choices of people living in poverty are usually complex and reliant on a range of circumstances. This is equally true of Western Cape informal settlements and was highlighted by the focus group interviews and other less formal conversations.

The complexity of energy choices is discussed by category in the sub-sections below. The State of Energy Report (City of Cape Town 2003) notes that although cost and availability are major influencing factors determining choice, perception and social acceptability also play a crucial role. In an attempt to gain an understanding within the study area a twin methodological approach was used. People were encouraged, both informally during the survey and in focus group discussions, to discuss how and why they chose a particular technology and the influence it had on their lives. The facilitators played an important role in encouraging people to relate their stories. Comments regarding the Ethanol gel, have been purposefully placed at the end of this section since, as this was the fuel being analysed, it provoked deeper discussion and therefore more voluminous information. A more rigid analysis of energy consumption and monthly spend through the survey data then followed. This data was captured on two occasions during the survey period.

#### **4.2.1 Electricity**

Anecdotal evidence indicated that many of the participants had access to electricity through both legal and illegal connections. The degree to which illegal connections occurred were difficult to measure as there was an obvious reluctance to discuss these. Electrical usage was seen in the analysis above as the most desirable energy source. Observations within the study area indicated that many homes were connected illegally, directly to power sources and also piggybacked on neighbouring connections, as can be evidenced in Annexure II. Numerous extension leads and cables crisscrossed roads and walkways between households. One participant admitted to sharing a cable from her cousin's house next door, which she used mainly for lighting and to play a radio, as she said batteries were too expensive. As she looked after her cousin's child during the day, she did not pay for the cable. The connection was in fact seen as part payment for the baby-sitting service. It was reported that some

residents who were legally connected charged a premium to surrounding houses to be able to plug into their connections.

A common comment from the sample group was that electricity was linked to housing and that if the government provided free houses then they should be provided with free electricity as well. The expressed view was that it was the ANC government that had promised both free housing and electricity in 1994, and that they were still waiting. It was coincidental that the long awaited N2 Gateway housing project adjacent to the study area housed its first eleven families during the last week of the survey. There was much animosity shown amongst the sample group as a monthly rental was being charged for the houses that they could not afford. Residents long established in Joe Slovo's Zone 31 were asked in the last fortnight of the survey to vacate their homes and move to Delft to make way for the next phase of the Gateway project.

#### **4.2.2 Paraffin**

Paraffin was referred to as the cheapest fuel source and tended to provide the greatest range of potential applications. Many Joe Slovo residents noted that as they came from rural environments predominantly in the Eastern Cape previous experience of paraffin use was well known. The main advantages according to the participants, was that paraffin could be used for the multiple purposes of heating, lighting and cooking. The appliance costs were relatively low and the fuel easily available. The paraffin was delivered by commercial suppliers, purchased from the refineries, in quantities ranging from 5000 litres to 200 litres and pumped into tanks and drums by truck at spaza shops within Joe Slovo, and sold on to local residents.

Amongst the sample group the fuel seemed to illicit strong emotion and was seen as a necessary evil. Seen paradoxically as a fuel of the poor the facilitators observed that there was reluctance by many in the group to admitting to using paraffin, particularly amongst younger members within the sample. Ideologically paraffin use seemed to imply notions of poverty and was therefore stigmatised. Comments from residents confirmed that a fear of fire and child poisoning were serious concerns associated with the fuel. The devastating fire of 2005 that burnt down 3000 homes leaving 12000 homeless and claiming the life of an infant, due to exploding primus stove (SABC News, 2005) seems to have left deep

psychological scarring. Despite these reservations, it has been noted in Section 3.3.2 that some 30 000 litres of paraffin still gets consumed in Langa every month.

In-depth discussions with the pilot survey cooks revealed that paraffin was a most useful cooking fuel for cooking traditional foods, as many of the dishes required long cooking times, and other energy sources were far too expensive. An additional benefit was that paraffin could be bought in small quantities. It was also noted that paraffin use formed part of a survival strategy during periods of financial scarcity. Many residents would even be willing to help neighbours and family by sharing small quantities of the fuel so that basic household necessities such as cooking, bathing and heating could be met.

#### **4.2.3 Liquid Petroleum Gas (LPG)**

The approach to Liquid Petroleum Gas (LPG) amongst the sample group crossed a veritable range of perceptions. In conjunction with the government's plans to decrease the load on the main energy utility ESKOM, a campaign to boost LPG usage occurred countrywide during the study phase. 72% of the sample group was supplied with a 9kg gas bottle and coupons that would allow for two half-price refills. This provided an ideal opportunity to assess how the community felt about this energy source.

The general perception seemed to be that gas was fast and efficient, but expensive. The proximity of two gas distribution depots in Langa meant that access to gas was not a problem, despite a shortage due to a national shutdown of a section of the refinery during the research period. The shutdown was met with much scepticism and there was a feeling that despite the government's well-meaning efforts, the poor had to bear the brunt of badly planned development initiatives. Several of the recipients sold their gas cookers and vouchers believing that the problems with accessibility to LPG would continue. The refill cost of the canister was about R150.00, and many saw this as a costly single outlay they would have to make on a regular basis once the vouchers were finished. Some recipients of the scheme - particularly those who had used gas previously - were encouraged by the initiative and saw LPG as becoming their chief fuel source in the future.

For many participants, even some who were positive about LPG technology, there was a strong association of fear relating to gas. The Zone 32 chairperson drew an analogy between

a gas canister and a bomb. He said that not only did it resemble the shape of a bomb but if it exploded it would react like one. There seemed to be a general perception that if one could not see the fuel it could not be trusted.

#### **4.2.4 Wood and coal**

As many of the adult residents of Joe Slovo were relatively recent arrivals from rural areas, they often had a strong association with wood as an energy resource. Although wood was not used very often by the sample group it was seen by many as the main fuel source of their rural past. For this reason it bears mentioning as a part of this conceptual analysis. Wood as a city fuel source was not seen as an appropriate technology other than for outdoor cooking. If wood was used, it was normally reserved for brewing beer in drums and to cook meat on a grid outside of the house. Occasionally large fires using wood formed part of traditional or cultural ceremonies such as weddings and liminal celebrations. In the main, use of this fuel source was prohibited by lack of access to firewood in the urban area and when it was available to purchase, its high costs of purchase.

Coal was well known as an energy source by many of the residents in Joe Slovo but hardly used. The South African literature acknowledges coal as a major fuel within informal settlements (Eberhard & Van Horen, 1995). The evidence within this literature tends to point out that coal is a popular choice of the poor in the Witwatersrand area where it is readily available. As coal forms no real significant part of the energy makeup in the Joe Slovo informal settlement, it warrants no more than this brief reference.

#### **4.2.5 Candles**

Paraffin wax candles tended to provide a significant lighting source and were used without exception by people in the sample group. Even when using other light sources candles were seen as a backup lighting when fuel ran out or power failures occurred. Fires from knocked over or neglected candles have been highlighted as commonplace within shack environments. As candles were used as a lighting source, they are mentioned here as a matter of completeness. Due to the fact that they were only used for lighting however, candles were not included in the comparative analysis with gel. Furthermore, candle purchases comprised only a small portion of the monthly energy budget. Market research

into the viability of introducing ethanol-burning lamps into informal settlements is currently being undertaken by several of the ethanol gel manufacturers.

### 4.3 Findings on the energy use patterns amongst the sample group

The synopsis above shows that Joe Slovo residents had existing attitudes towards a range of energy carriers before the introduction of the Ethanol gel fuel option. The survey questionnaire was used to establish the breakdown of what sources were used and for what purposes. The sample population was questioned at the first gel distribution and then again at the end at the last distribution. Participants were encouraged to monitor how much energy was consumed, and then on what function that energy was expended over a month. Through the quantitative data a profile of energy use could be compiled and compared over time. It would then be possible to determine to what degree the new biogel was being utilised and what purpose it fulfilled within the household. As wood was not seen as either highly desirable or used extensively, it was not seen as viable category to include in further research.

#### Measurement

We noticed that participants were comfortable presenting figures for measurement for the different energy carriers in a variety of dimensions. Electricity was always measured in monetary terms across time, gas by cylinder over time, but liquid fuels in either financial terms over time or by physical liquid measure. Paraffin was often referred to in two-litre measure quantities; normally a Coca-Cola bottle and this seemed to be the most popular quantity of purchase and receptacle of choice.

For the purposes of developing a common denominator across the different variables, participants were encouraged to provide the research team with a monetary breakdown of energy by carrier per month. These figures were then averaged across the sample size and converted to percentages. It was also deemed necessary to establish what energy was being used by application. These figures were grouped together by application type and averaged to provide a percentage. There was one participant within the sample who ran a spaza shop from home who spent some R600 per month on electricity. Her data was removed from the sample as it skewed the figures too dramatically.

Table7

Energy carrier measurement

### 4.3.1 Energy use patterns at the beginning of the survey period

Figure 6 below highlights that paraffin is the main energy source and has a multiplicity of uses amongst the respondents. Surprisingly, electricity plays an important role in many households and was seen as the most desirable lighting source, but too expensive for cooking. It was reported by those who did use legal electricity that they thought that purchasing electricity from the local supermarket was more expensive and they got, “less power” for their money, then if they paid monthly by municipal electricity bill.

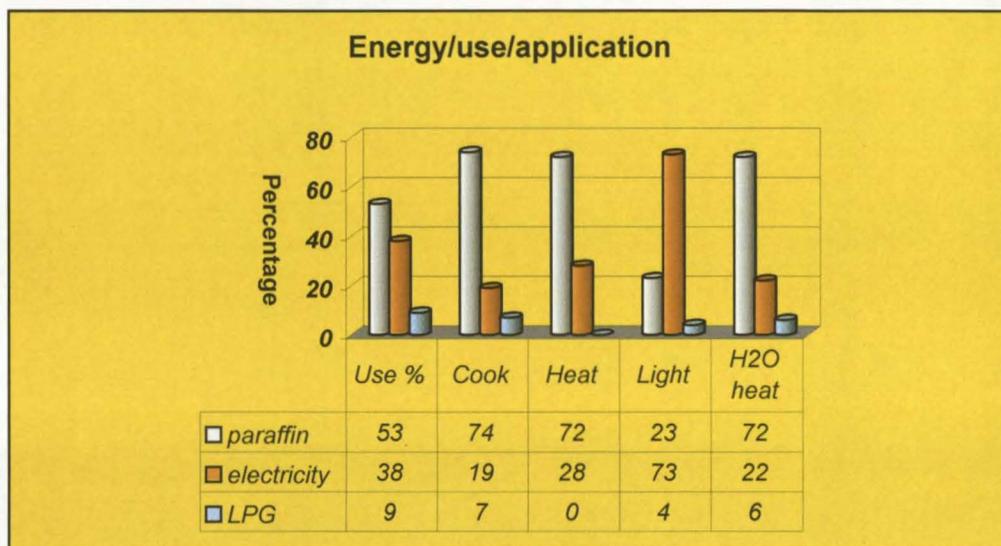


Figure 6  
Energy by use and application

Note: The sample size fluctuated dramatically during the period of analysis. Converting all values to percentages helped to overcome these problems. As we were looking for a trend to analyse the effect after the gel distribution, it was deemed adequate to use percentages across both data sets.

LPG as a fuel source was not used extensively at the time of the initial questionnaire for reasons of fear and cost per gas bottle as already mentioned above. The reason for including gas as an energy source is that many initiatives are currently underway to encourage South Africans, irrespective of Living Standards Measure (LSM) grouping, to use LPG. These initiatives are driven in the main by demand side management (DSM) initiatives by ESKOM to curtail electricity usage by its customer base especially during peak periods.

As the survey was conducted over the cold Cape winter months, space heating was an important component of the analysis. Heat was derived from paraffin heaters that sometimes doubled as stoves. Primus and flame stoves were also reported as being used as heating devices. On cold evenings and in the mornings, water would be put on stoves to simmer and the steam emanating from the pot used to heat the home. Residents were encouraged to monitor the duration of this process and families using the technique reported a range of time periods from half an hour to three hours per day. Clearly for some residents the practice was a fairly considerable contributor to the monthly energy expenditure. Cowan and Mohlakoana (2005) noted in their 2004 survey conducted in Khayelitsha that bulk heating of water in poor households using electricity was becoming more commonplace. This did not seem to be the case in Joe Slovo. It would seem that a logical explanation for the disparity between the two areas is that Khayelitsha generally has greater access to the grid. A difficulty encountered with accurately assessing this practice was that the hot water that was used for heating was then often used for secondary purposes such as bathing or cooking.

As was expected, a large proportion of cooking, some 74%, was conducted on paraffin stoves. This was considered to be a major contributor to household energy expenditure. The biggest driving forces behind why paraffin was so extensively used for cooking seemed to lie as much in the cheap appliance cost as the ability to purchase small quantities of fuel. Primus stoves retail from local stores in Cape Town for around R145.00, while the Panda flame stove could be purchased for R25.00. The convenience of being able to purchase only a litre or two of fuel at an outlay of around R4.50 per litre was consistent with strict budgetary constraints. Therefore, if gel was accepted as an alternative fuel, it would be in this area that the greatest impact would be realised.

#### **4.3.2 Energy use patterns at the end of the survey period**

With an understanding of the energy profile sketched above, it is now possible to compare what influence the bio-ethanol gel fuel distribution had on the energy use patterns of the sample population. The survey questionnaire was used to understand the various applications that the specific carrier was used for and how these different carriers crossed many boundaries determined by availability and circumstance.

It was deemed critical to the outcome of the research and for the purposes of testing the hypothesis, to gain an understanding as to the degree to which the biogel was being used. The research capacity was limited to provide only a trend against which the pre-gel energy scenario could be measured against the post-gel distribution. The analysis with the other data from this section would then go some way to providing the first dimension of the sustainability assessment, the social angle.

Ethanol gel at this point cannot be practically utilised for either lighting or directly for heating. However, it was decided that as these two applications played such a major role in the average monthly energy expenditure, it was only right that they should remain as class categories within the analysis. A significant reason for choosing a specific energy provider does after all have a lot to do with its ability to perform several different functions, as has been noted above as is the case with the cross functionality of paraffin stoves.

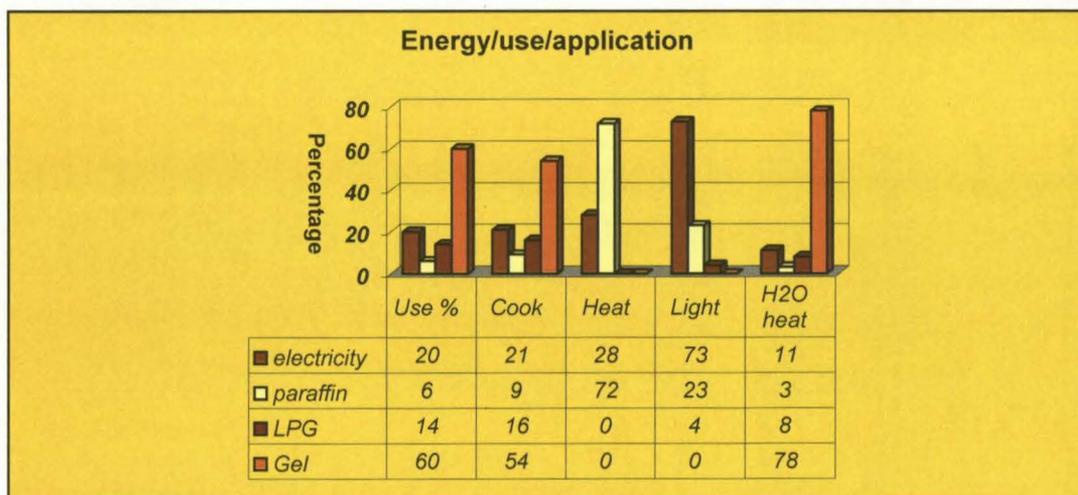


Figure 7

The energy/use/application graph including gel.

The above graph and table indicates that after the introduction of the gel, it was extensively used by the sample population for cooking and heating water. The provision of free gel effectively reduced energy expenditure over the survey period by approximately 60%. As mentioned above, the gel technology was not deemed suitable for heating or lighting and therefore not measured here. However, the money freed up over the study period would have allowed participants to spend more on these two areas. The table below excludes the

applications of heating and lighting and provides a direct comparison of energy carrier use before and after the introduction of ethanol gel as a free option:

**Pre and post gel energy carrier use by consumption**

Source	Use %		Cook %		H2O heat %	
	Before	After	Before	After	Before	After
Electricity	38	20	19	21	22	11
Paraffin	53	6	74	9	72	3
LPG	9	14	7	16	6	8
Gel	-	60	-	54	-	78

Table 8

Over the study period, table 8 shows that LPG use had increased by spend, use and functionality. The roll-out of the LPG programme by Eskom took place just prior to this segment of the survey. It is believed that the voucher system would have been responsible for the increase in gas use. It therefore gives a good comparative trend as the gel was also provided free of charge.

What is most significant about the above figures is that they show a dramatic shift in energy use for the functions of cooking and water heating. A significant portion of these functions that were usually performed on paraffin stoves prior to the gel introduction seemed now to be readily performed on gel stoves. Whether the popularity in gel use was purely a matter of financial opportunism or not could not be established by this study alone. Focus group interviews and insights gained during the more technical phase of this research go some way to answering this question, although it is not conclusive. What was most significant about the above figures is that stove based functions of cooking and water heating on paraffin stoves after the gel introduction seemed to have been readily performed on gel stoves. What could be deduced from the figures is that the local population were happy to change from using a specific fuel source to an alternative if a financial advantage could be realised. The comfort of using an energy source that was safer and less noxious than paraffin was an additional factor that encouraged the use of the gel.

## **Chapter 5: Comparative analysis**

Against the background of the information gathered about energy use patterns and ethanol gel-based energy resources in particular, as set out in the chapter 4, the next step was to consider what the implications of these findings may be on a broader scale. The discussions in this chapter consider the following questions:

- What are the present and potential financial implications of using various energy sources in an informal settlement context?
- What are the environmental and health implications of using the various energy sources in informal settlements? and
- What are the longer term sustainability prospects for each of the main energy sources?

### **5.1 Financial analysis**

To compare the various energy carriers from an economic point of view, several different factors need to be examined. Shelf price or final selling price of the product is the greatest influencing factor determining choice amongst the poor. This study examines levels of financial viability in line with the overriding theme of sustainability, incorporating the social and ecological paradigms. Rigorous product related financial research can no longer take place in isolation. The results of globalisation, world politics and the financial disparity between rich and poor nations all have major effect on both the base manufactured price and delivered price of commodities. Vital to a financial analysis of an energy carrier is an examination of the external costs that are generated throughout the life of the product. The section examines externalities and the resultant costs that they have on different energy carriers.

#### **5.1.1 Paraffin**

We have seen how the bombing of the world trade centre and the war in Iraq has had serious financial ramifications across the globe. Share prices rise and fall dramatically, influencing the movement and cost of basic resources. The South African oil price, pegged

to the American dollar, is no exception to this rule Illuminating paraffin is manufactured from crude oil. According to figures supplied by SAPIA (2007), prices have risen disproportionately but in virtual log step with the international barrel price of oil. Every effort is made to keep the petroleum price in South Africa as low as possible, as it has such an important effect on the economy. Yet, the same cannot be said for paraffin. The outcry from middle class consumers and industry over rising petrol prices tends to often make headline news in the mainstream media. Not surprisingly, paraffin price escalations often get no more than a passing mention. This is despite the fact that illuminating paraffin comprises some 7% of household energy use within the country (City of Cape Town, 2003).

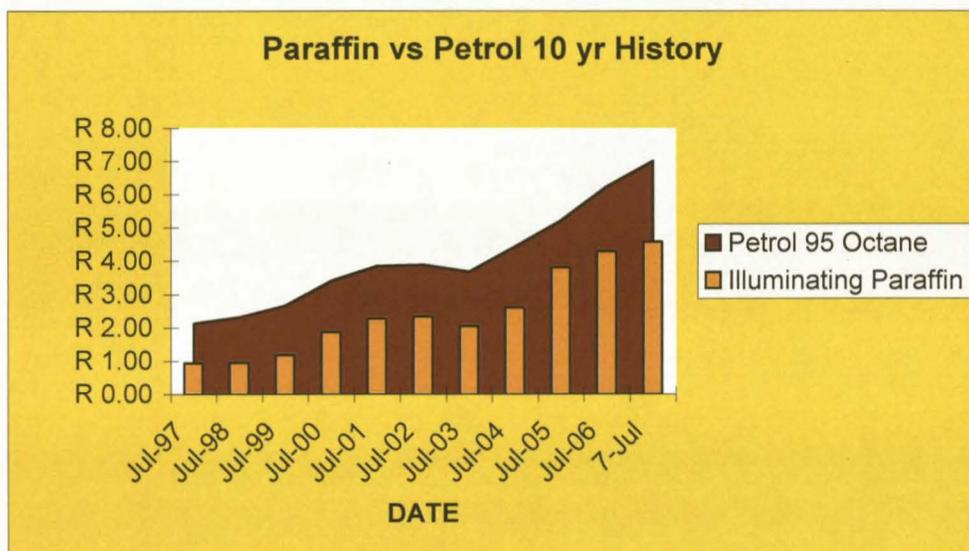


Figure 8  
History of paraffin and petrol prices. Source: SAPIA reports (1997-2007)

The graph above shows that an increase of R 3.64 took place in the paraffin prices between 1997 and 2007, whilst petroleum went up by R4.86. When expressed as a percentage, petroleum has risen in price by 227% but paraffin by 387% over the ten year period. Despite the zero vat rating that paraffin enjoys, and a controlled gate price at the refinery, prices on the street vary dramatically. A brief survey conducted with the help of a few of the participants illustrated that paraffin prices from spaza shops in Joe Slovo fluctuated by as much as 75 cents per litre. The cheapest available paraffin was R4.50 and the most expensive R5.25 per litre.

### **5.1.2 Liquid Petroleum Gas**

LPG prices have also continued to rise steadily over time. One of the reasons alluded to earlier for the unpopularity of LPG within the study area is the fact that LPG can only be purchased in fairly large containers. A 9kg gas refill retails for between R123.00 and R185.00 and lasts users on average four days when used exclusively for cooking and water heating.

LPG prices are not regulated in the same way that petrol and paraffin are. In terms of the legislation there is only a maximum refinery gate price for LPG but this only pertains to the refineries themselves. At the time of writing this price for LPG was R5.44 per KG for the period 1 July to 31 July (DME, 2007). This meant that by the time LPG is sold over the counter a mark-up of approximately 300% is realised. The Minister of Minerals and Energy recently announced that price controls from government on LPG would be put in place (Business Report, 2007).

Both paraffin and LPG are dependent on fossil fuels. If expert reports by Heinberg (2003) and Roberts (2004) are to be taken seriously, then oil price increases will steadily continue as we move towards peak oil. The long-term scenario is that fossil fuel-based products will become less and less viable purely on the basis of affordability, especially for those already facing low, erratic and irregular incomes.

### **5.1.3 Ethanol gel**

Ethanol gel prices are determined in the main by the base price of raw ethanol. Berg (2004) shows how between 70% and 80% of ethanol costs are derived from its respective raw material. Biogel is manufactured from ethanol derived from the fermentation of plant materials. Within a South African context the majority of ethanol for gel produced to date has been derived from sugar cane bagasse, a waste product that is a residue from the refining process. Increasing demand for ethanol has had a dramatic effect on prices in the market place and the previous elasticity that existed from the refineries has been severely diminished (South Africa Sugar Association, 2006).

The recent upsurge in popularity in gelfuel particularly in Kwazulu Natal's rural areas has seen an increase in gel manufacturers and gel production. Kevin Cavanagh from Illovo, one of the main sugar refining companies in South Africa, indicated that they were looking into establishing an Ethanol gel plant themselves (Cavanagh, 2006). As one of the major sources of ethanol for the gel market, this would place a virtual stranglehold on ethanol supply to smaller manufacturers. As a consequence of a steady supply of ethanol directly from source at cost, existing infrastructure, reduced transport costs and ready access to credit the refining company would certainly realise a competitive advantage. If the cost benefits were passed onto the poor a considerable saving in the final gel price could be realised. The possibility of manufacturing ethanol from waste streams in other industries certainly requires future investigation.

The moral dilemma of attempting to analyse and measure the economic efficiency of a product against the basic livelihood necessities of the poor, whom that product is intended to help, is a complex issue. The competition between feeding a population and growing a crop for energy needs to be carefully considered along ethical, as well as financial lines. It is not the intention of this work to investigate the circular argument on the food or fuel debate, but it is deemed necessary to briefly examine the potential financial viability of practical ethanol production from various feedstocks. Issues surrounding the ecological ramifications of growing a feedstock for fuel are investigated below. It is however mentioned here as the economy ecology dichotomy goes to the very heart of the notion of sustainability and when armed with that knowledge no single paradigm can be analysed in isolation. An economic loss or gain in one area may result in an ecological or societal gain or loss in another.

Producing a model to predict the potential financial viability of producing ethanol from different feedstocks is a complex exercise. Currently South Africa produces approximately 100 million litres of ethanol through fermentation of feedstocks per annum (Thomas and Kwong 2001 in, Dawson Bester and Austin, 2006). Sugar cane is currently the chief source of ethanol in South Africa and is grown in the Eastern Cape, Kwazulu-Natal and Mpumalanga. According to the South African Sugar Association, approximately 21 million tons of sugarcane was to be harvested in the 2005/2006 season with a refined mass of about 2.5 million tons of sugar (Department of Agriculture, 2005).

According to figures based on work conducted by Dawson Bester and Austin (2006), an ethanol production yield of some 100litres of Ethanol could be produced from a ton of sugar cane bagasse. The ethanol production from sugarcane cost calculated by Dawson et al is approximately R1.59 per litre. Figures from the same authors further indicate in the table below how other feedstock ethanol yield production costs compare.

	Cost	EthOH Yield	EthOH Yield	Crop Yield	Feedstock Component	
	(R/ton)	(l/ton)	(l/ha)	(Ton/ha)	(R/l)	(US)
SA Maize	897	421.6	1385	3.3	2.13	35
SA	160	100.9	6600	64.4	1.59	26
SA Sweet	121	100.6	2100	20.9	1.20	20
SA Waste	150	83.8	—	—	1.79	30

Table 9. Source: Dawson, Bester and Austin (2006)

Comparative RSA Feedstock Ethanol Yield and costs

The fluctuation in production costs and ethanol yields across the various feedstocks would naturally be dependent on a number of variables, but the table above provides a starting point from which to make certain logical assumptions. It is clear that maize has the highest feedstock component cost for ethanol production per ton, and this is predominantly due to the low crop yield of only 3.3tons/Ha. Since the above research was conducted maize prices in South Africa have gone to R2000 per ton the natural consequence would be a dramatically escalated price of ethanol production by some 130%.

Although waste fruit shows the lowest ethanol yield proportions, there is a reasonable feedstock cost factor. Transportation of waste fruit to ethanol production plants would have a dramatic effect on the figures provided. Dawson Bester and Austin (2006) show through a of series of calculations based on ethanol production costs, how sugar derived from waste fruit on Western Cape farms could potentially realise the greatest investment from any feedstock. What is not taken into account within these calculations is the externality costs of planting a crop specifically for fuel production. In such an instance, additional consideration would have to be given to the cost to the environment through water extraction, potential land degradation, and the utilisation of arable land that could otherwise be used to grow a crop for feeding the very poor.

Environmental and socio-economic costs are difficult to equate utilising linear Fordist measures. Pimmental (2002) maintains that the embodied cost required to manufacture ethanol makes it an uneconomic fuel source that relies on fossil fuels for its manufacture. He states that the energy input to produce 1000 litres of ethanol is about 8.7million kcals but the energy value of that 1000 litres is only 5.1 million kcals. This represents a 70 % increase in the production phase compared with the energy content of the ethanol.

A model considering these externality costs would logically show biased results in favour of ethanol production from an existing feedstock as apposed to one that is being recycled to create a secondary resource. In the above analysis, waste fruit appears to meet both financial and reusability criteria, making it the most viable option.

#### 5.1.4 Comparative Financial Analysis

To determine the relative comparative financial sustainability of paraffin, LPG and ethanol gel, it was deemed necessary to establish the unit price of each of the carriers directly compared with one another. The unit of measurement used to achieve this is R/MJ which gives an indication of useful energy over cost.

	Energy Content MJ/Kg <sup>1</sup>	Thermal Efficiency % <sup>2</sup>	Effective Energy Content MJ/Kg	Energy Cost R/Kg <sup>3</sup>	Useful Energy Cost R/MJ
Paraffin	46.1	20%	9.22	R 6.32	R 0.69
Gas	49.4	50%	24.7	R 13.85	R 0.56
Gel	22.8	50%	11.4	R 4.68	R 0.41

Table 10

Fuel price per energy measure

Notes:

<sup>1</sup>. The Kg measure for the calorific value of energy content has been deliberately used so as to maintain a consistent value especially significant for LPG which is sold in Kilograms. The energy content was sourced from the Biomass Technology Group (BTG, 2001)

<sup>2</sup>. Thermal efficiency was derived from Van Wyk (2004) who ran analytical tests through the SABS for Enviro Heat, a local gel manufacturer. Some sources such as Cowan (2005) and The State of Energy Report for Cape Town (2003) show a thermal efficiency of approx 50% and PASASA (2003) as high as 63%. It must be noted that these figures are based on primus stoves. The stoves used within the study and by most of the participants were cheap wick stoves.

<sup>3</sup>. The energy costs used for Table 10 in rands were derived as follows:

- Paraffin – average available price from survey conducted within Joe Slovo. See 5.1.1
- LPG – average available price from survey conducted with Joe Slovo. See 5.1.2
- Ethanol Gel – the base price paid for the study from the retailer.

It must be noted that densities to convert from liquid measure to mass were required. For paraffin this was 1300 ml/kg & for gel 850 ml/kg.

We can observe from Table 10 that at current prices gel is in fact the cheapest option. It should however be noted that the additional simultaneous useful outputs of the paraffin burners (e.g. heat produced while cooking) are not reflected in this simple price comparison. It must be noted that in work recently conducted on several gels and stoves by Lloyd and Visagie (2007) efficiency values varied between 30% and 60%. Overall however, if we were to add the externality costs involved from a safety and health perspective and then the environmental factors, gel and specifically the gel and appliance used in this research would certainly reflect a far more sustainable option.

## **5.2 Environmental and health analysis**

Within the context and spirit of sustainable development, it is crucial to explore and evaluate the environmental impacts of utilising specific energy carriers. Household energy practice is one area in which small local changes implemented today can have global ramifications now and into the future. Global warming is the central common environmental issue that could and should focus the international community to work together because as we are reminded by Clayton (1995) “a molecule of greenhouse gas emitted anywhere becomes everyone’s business.”

Predictions based on research performed by Winkler et al (2006) show that if kept unchecked, Cape Town’s own contribution of carbon dioxide emissions will increase from 16.1 million tons (MtCO<sub>2</sub>) measured in 2001 to 23.6 MtCO<sub>2</sub> per annum by 2020.

Many well-meaning projects (and often those that are put in place to help the poor), are not examined from the perspective of the environmental impacts those projects may have many miles away from where they are being implemented. The global commons, as pointed out by Najam (2000) while referring specifically to the atmosphere, needs to be both used and protected by all. An environmental analysis of energy use needs therefore to examine both the immediate vicinity in which a specific carrier is being used and the larger scale consequences. An appropriate comparative tool used extensively by Botha and Von Blottnitz (2006) to measure the environmental impact of ethanol from different feedstocks is their Life Cycle Assessment (LCA). The LCA accounts for the full life cycle of a product

from cradle to grave. It is not specifically the scope of this document to analyse the environmental impact of the various energy carriers in the study area. It would therefore be beyond the practical purposes of this work to delve too deeply into the life cycle assessment of each energy carrier used. However, the assessment undertaken here is loosely based on the concept of LCA and acknowledges the potential value in the tool to model environmental impacts.

Marginalized communities living within the tight constraints of the urban fringe often have to make do with limited available space and limited resources from which to construct their dwellings. Joe Slovo is no exception to this rule and amongst the sample group involved in the survey, four people on average occupied a shack with a floor space of around 16m<sup>2</sup>. Cooking and bathing activities usually took place first thing in the morning and in the evening. During the cold Cape winter, doors were often kept tightly shut against the elements to maintain as much heat indoors as possible. The effect of combustion pollutants on families through fuel emissions in the study area was exacerbated by the confined overcrowded areas in which they lived.

### **5.2.1 Environmental and health impacts of LPG**

LPG is not visible and the only way gas leaks are detectable is by smell. In confined environments the results of being overcome by gas fumes or lighting a match in a gas filled shack could be lethal. The extraction impacts of LPG are similar to those of oil from which paraffin is derived. LPG is a direct by product of the oil refining process so is perhaps tarnished with the same environmental impacts as the oil business per se. However, in its combustion it is perhaps the cleanest of all fossil fuels. Utria (2004) shows in a comparative cooking test that emission ratios for an LPG stove are 3028g/Kg of CO<sub>2</sub>, compared with 3127g/Kg when the same meal was cooked on a paraffin wick stove. As LPG was not used extensively by the sample population it was difficult to gain an unbiased and true reflection as to how it was seen on a local environmental scale. The few people who did use gas on a regular basis did comment that it was far healthier than paraffin and that it did not give off soot the way paraffin did.

### **5.2.2 Environmental and health impacts of paraffin**

The clear colour of paraffin means that it is often mistaken for water and consumed by young children causing severe poisoning which are occasionally fatal (Kruger, 2004). Many of the participants in the survey highlighted the fact that paraffin fumes were noxious and responsible for a range of respiratory problems. They went further by indicating that those who suffered the most were often small children and babies

Reports that paraffin in fact emitted immense amounts of smoke that were not always visible, were confirmed during the cook-off phase of the study, by observing the bottom of pots. Many of the sample group stated that their pots after cooking with paraffin were black and that it took intense scrubbing after cooking with paraffin to clean them. The molecular weight fraction of illuminating paraffin is high due to its illumination requirements. The soot that is burnt onto the bottom of pots consists of unburnt hydrocarbons that are very fine, in the range of  $<2.5\mu\text{m}$  the level at which respiratory inhalation is possible (Lloyd, 2002). Kruger (2005) maintains that due to the pyrolysis phase in paraffin manufacture, the soot that is given off from paraffin stoves during cooking is carcinogenic.

According to health standards published by PASASA (2003), the acceptable emission ratio for CO and CO<sub>2</sub> is a ratio of less than 0.02.Kg per MJ of energy. A compilation of data analyses of CO<sub>2</sub> emissions from various sources (Utria, 2004; State of Energy Report for Cape Town, 2003) indicate that CO to CO<sub>2</sub> levels of from paraffin wick and primus stoves are in the order of 0.07kg/MJ.

### **5.2.3 Environmental and health impacts of electricity**

The State of Energy Report for Cape Town (2003) showed that on average, low income households emit 146Kg of CO<sub>2</sub> per month, while middle and high-income homes using electricity emit some 737kg. The City of Cape Town Sustainability report (2005) indicates that Cape Townians are currently responsible for 6.27 tonnes of CO<sub>2</sub> per capita per annum. This is up from a measurement of 5.8 tonnes in 2001 and very high when compared to the global average of 3.98 tonnes of carbon dioxide. The African average is 1.1 tonnes per capita. Electricity is often mistakenly seen as a clean fuel at sight of delivery, when you

ignore the emissions produced at source. The costs of burning coal for South African power stations put 306.3 metric tons of CO<sub>2</sub> directly into the atmosphere in 2002 (Eskom,2005). Electricity from nuclear power is seen by many to be substantially cleaner and far more environmentally friendly. Nuclear power plants have (with one or two exceptions such as Chernobyl and Three Mile Island) enjoyed relatively good safety and environmental records. The possibility of a catastrophic disaster does always exist and needs to be factored into an environmental analysis on energy carriers along with the problem of waste disposal.

The well-meaning official target to electrify every household in South Africa by 2014 does seem to be somewhat unrealistic. During the survey phase of the study the vulnerability of the electricity grid was highlighted as Koeberg had to shut down its one generator causing severe power cuts within the Western Cape. The problem was exacerbated during peak load times on the grid. The National Energy Regulator (NER) and ESKOM (2005) have admitted that the grid did not have the capacity to carry the current load, let alone new installations, unless new power stations were built or old coal fired power stations were re-instated. As part of a lifecycle analysis of the energy regulator to produce electricity, a full assessment of the entire infrastructure from the beginning of the generation phase to delivery would need to be looked at. This would in the case of coal-fired power stations include the coal extraction process and the environmental impacts and externalities caused by it. In the case of a nuclear facility an audit would be required to include the uranium mining and potentially hazardous disposal processes of the radioactive waste.

A study conducted by Spalding-Fecher and Matibe (2003) claims that the particulates especially PM10, given off from coal burning power stations are directly responsible for respiratory illnesses amongst those within close proximity. Seen solely from an environmental perspective, electricity in its current production format in South Africa cannot be seen as a sustainable energy source. While efforts are underway to examine the potential move away from fossil fuels to renewables for electricity generation, until this occurs, electrification cannot be seen as an environmentally-responsible option.

### 5.2.4 Environmental and health impacts of ethanol gel fuel

The new fuel was accepted with great anticipation. The three participants who cooked during the pilot study were each given a stove and five litres of gel and persuaded to use the gel and speak to friends and neighbours about it. Work by Tilimo and Kassa (2004) showed that there were high levels of acceptability of gel shown in poor household markets throughout Africa. By the time the research team introduced the gel to the community many of the participants had heard of the new technology. Having a mayonnaise-like consistency, ethanol gel will not run or spill if knocked over like other liquid fuels. It is usually green in colour, making it immediately distinguishable from most other household substances. The gel is manufactured from ethanol mixed with a gelling agent such as Hydroxy Ethyl Cellulose or carboxymethylcellulose and water. A bitter-tasting additive such as Bitterex is then added to avoid consumption. Water can make up between 10 and 25% of the gels content and this has a direct bearing on the heating value.

Ethanol gel fuel is a relatively clean-burning substance, having a direct CO<sub>2</sub> to cooking ratio far less than paraffin or LPG. The product produces negligible amounts of local emissions when burnt. Table 10 provides a direct comparison between the three fuels, showing the immediate direct benefit of gel over other carriers.

<b>FUEL</b>	<b>Amount of fuel used (kg)</b>	<b>CO<sub>2</sub> Production (g/Kg)</b>	<b>CO<sub>2</sub> emission (g/meal)</b>	<b>Comparative emission ratios</b>
LPG	0.188	3028	569	119.8
Paraffin	0.205	3137	643	135.4
Ethanol gel	0.310	1533	475	100

Table 11 (Source: Utria, 2004)

Emission comparison

As with the other energy carriers, one needs to refer to the product's full life cycle to appreciate the potential externalities involved. The chosen ethanol source and production

process<sup>7</sup> are two major elements influencing the degree to which the product impacts on the environment. As the majority of ethanol for gel manufacture is currently produced from sugar cane bagasse after the refining process, this can be seen as a subsidiary action having secondary impacts on the environment. It is slightly more complicated to statistically measure the impacts of the sugar growing and refining processes, which are the primary impactors. Land use for cane growth, biodiversity loss, water, fertilizers, and transportation from seeding to harvest must all be seen as a part of the sugar business and can therefore not independently be included as part of an LCA. If a feedstock were specifically grown for ethanol to produce gel fuel, this would become the primary business and therefore environmental impacts would need to be measured accordingly.

A common impact that does exist across all energy carriers is the impact that occurs between production and delivery. Logic dictates that the greater the distance between these two points, the greater the impact will be. As ethanol can be manufactured from a variety of sources, the closer the ethanol production plant is to the gel manufacturer, the less the impact would be. As observed in the financial assessment transportation is a major proportion of a products marketable viability. Locally available source material, with high yield rates and the least work in the production phase of ethanol seem to be the major determinants affecting the level of impact on the environment.

### **5.3 Sustainability assessment**

From the findings above it is possible to draw certain conclusions as to the levels of sustainability of the energy carriers used within Joe Slovo. Table 11 provides an overview of those findings and synthesizes the data from the various analyses. While many areas tend to overlap the social, environmental and economic paradigms, it must be remembered from the explanation in Section 3.2.1 provided by Goodland and Daly (1996) that the interaction between these elements is one of the main tenets of sustainability.

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<sup>7</sup>Lloyd and Visagie (2007) have shown in recent tests that the consistency in the make up of gels from differing manufacturers varied widely and how this had a direct result on the CO to CO<sub>2</sub> emission ratios.

	SOCIAL				ECONOMIC				ENVIRONMENTAL		
	Household emissions	Safety impression	Ease of use of the appliance	Multi functionality	Appliance cost	Energy cost	Employment opportunities	Source supply and demand into future	Green house gases through LCA	Infrastructure	Source availability into the future
<b>Electricity</b>	NA	Unsafe when illegal and in the rain if the house leaks.	Very easy to use. Fast and Efficient	Can be used for all energy requirements	Very expensive	Connection fee too expensive, can't buy small units	No job opportunities for poor or unskilled in this sector	South African electricity costs will increase into future. Coal price competition with export market	South Africa reliance on coal fired and Nuclear power bad for the environment	Massive grid infrastructure required. Process decentralised from production to supply	South African coal predicted to last 80-100 years. Renewable policy too slow
<b>Paraffin</b>	Heavy emissions. Respiratory problems	Exploding stoves, Paraffin leaks, poisoning	Stove needs regular cleaning, leaves pots dirty	Cooking, heating refrigeration and lighting	Cheap wick stoves and lights affordable for all	Most practical can buy small quantities, best value when money's low.	Sale of paraffin from spazas and shops provides small revenue for some	Oil prices set to increase into future with peak oil. Competition in refining process equals increased paraffin cost	Fossil fuel base highly processed heavy refining emissions, CO <sub>2</sub> , NOX, SOX. Into atmosphere.	Refined from crude oil extraction to refining requires massive infrastructure	Peak oil already reached need to look towards alternatives
<b>LPG</b>	Slight emissions but can smell fumes	Exploding stoves, Cannot see fuel if left on. Dangerous	Complicated unexplained technology	Cooking, heating refrigeration and limited lighting	Too expensive unless subsidised	Gas can only be bought from 9kg up, must fill container can't afford it.	LPG safety restrictions and infrastructure costs too high for entry of poor.	LPG price increase into future as more efficient then petroleum competition for remaining supply	Fossil fuel base high. Externalities in extraction and manufacture	Refined from crude oil extraction to refining requires massive infrastructure	Peak oil already reached need to look towards alternatives Competition with petrol in future.
<b>Gel</b>	No emissions can smell when blown out.	Feels very safe to work with, non toxic advantage	Easy to use but stove reservoir too small for big meal	Only used for cooking, heater and lighting could be useful in future.	Prices must come down or quality improve	Container size must be appropriate to affordability.	Opportunities exist through ethanol production, gel manufacture and sales.	Increasing prices of ethanol from current suppliers make gel currently financially not viable. Ethanol from waste into future could change this.	If derived from secondary waste source less externalities. Low manufacture inputs to the environment.	Minimal infrastructure required for small scaled localised plant less impact on environment	Waste materials becoming more abundant. Ethanol from recycled waste products viable into future

Table 12  
Sustainability Assessment

The sustainability assessment table provides a summary and conclusion to the findings presented through Chapters 4 & 5. The table has been constructed through the identification within the data analysis collation, together with components extracted from the literature review and various interviews. It is clear that each of the technologies have certain merits when defined within the strict parameters of a single vector. When the technology is observed throughout its profile and compared within the sustainability matrix a completely separate image emerges. By example we can note that ethanol gel appears to have very strong environmental advantages but tends to suffer from financial constraints unless it is able to be manufactured locally and possibly derived from waste streams. In contrast paraffin has a very strong financial appeal but presents itself as environmentally detrimental.

In accordance with the original definition of sustainable development highlighted in Table 2, it is deemed imperative to go beyond the parameters of merely analysing the social, economic and environmental but to look toward the influence of initiatives into the future. The biggest constraints looking forward are: diminishing coal reserves, the time lag to meet renewable energy targets and peak oil. These limitations which will dramatically affect electricity, paraffin and LPG need to be urgently addressed. As further pressure through increased demand is placed on the South African electricity network and oil continues to move towards \$100.00 a barrel the urgency to look towards alternative and more efficient energy supply could not be more pressing.

## Chapter 6. Conclusions

The study described above provides insight into the viability of ethanol gel use as an energy source within the Joe Slovo informal settlement of the Western Cape. The only way to effectively produce an analysis of a product used within a specific context is through a comparative exercise that includes what was used before, during and after the products introduction. Although this was a study undertaken within an informal settlement within the Western Cape it went some way to confirming the seemingly national assertion in the literature that the poor used a mix of energy carriers. What must not be taken for granted by future researchers is how and why a specific carrier is chosen within a specific context.

Much previous work on energy has tended to focus on a single specific aspect of a target population. This fact was evidenced within Joe Slovo during the course of this particular study with the subsidised LPG rollout and the Carbon Fluorescent Light bulb (CFL) distribution. Neither of these well-meaning exercises undertaken on behalf of Eskom was accompanied by a true participation process to explain the motive behind the initiative or to describe the technology. Many of the population indicated that they were sceptical of Eskom's intentions and maintained that they would rather have been connected to the electricity network, as that was, "what Eskom did". This was despite the fact that Eskom's intention was to relieve pressure on the grid at the time.

The research to establish the level of sustainability of the ethanol gelfuel was by contrast greeted with what seemed like much enthusiasm by the survey group. In spite of losing several stoves and gel at the rollout stage of the survey, the experience ironically seemed to strengthen the relationship between the research team and survey population. The intensive ongoing interactions provided several opportunities to explain the technology as well as deepen the understanding and gain a true appreciation for the participants' requirements.

The paradoxical argument from government that electrification for the poor will coincide with housing delivery ignores the immediacy with which initiatives need to be put in place. Even if the unrealistic goals of housing the South African population by 2014 is reached, there is much doubt that subsidised housing will financially be able to incorporate

electrification. ESKOM and the NER have indicated that there is already severe pressure on the grid and additional power utilities need to be built to facilitate current usage. To date no meaningful emphasis has been placed on incorporating renewable energy carriers into the power matrix; the strongest public sector lobby seems to be in favour of more coal fired and nuclear facilities.

While paraffin enjoys the competitive advantage through the incentives put in place by the government it will remain an economic choice of the poor. With crude oil prices increasing into the future, as we begin to realise the effects of peak oil and increased global demand, there will no doubt be a neutralising effect on these incentives. Initiatives to zero rate ethanol and gel fuel would go some way to putting the gel product on an equal financial footing. A strict price control would prevent unscrupulous retailers of exploiting the poor as has been the case with paraffin. If community run cooperatives were established controlling the process from gel manufacture to distribution, the supply chain would be shortened thus cutting out several middlemen.

At a macro level the impacts and consequences of using electricity from the grid are easily independently identifiable and quantifiable. On a micro scale vectors that can be used to measure sustainable development are equally as simple to formulate. What is complex is to provide a quantifiable cross-section of the impacts of emissions from coal burning or hydro generation electrification compared with the impact of burning a single candle or paraffin stove in a household environment.

The direct environmental advantages from burning ethanol as a cooking fuel rather than paraffin at a local level cannot be underestimated. When observed through the full life cycle analysis the gel based product certainly seems at present to have environmental advantages from cradle to grave over many other energy carriers. These effects could be further mitigated if local production was implemented thus lowering energy used for transportation.

The single greatest benefit derived from the use of the ethanol gel and the initial motivation behind this study lay in the fact that the product was seen as safer than using either LPG or paraffin. The cost benefit to the health sector and emergency services of minimising shack fires within informal settlements cannot be undervalued. Of even greater importance would

be the knowledge that a safe, reliable, non toxic substance is being used in the home providing a sense of comfort and social acceptability.

The intention of this study was to establish the level of potential sustainability of ethanol gelfuel within a Western Cape informal settlement. One of the most critical realisations has been the need amongst the poor for a range of energy carriers. While this study has gone some way to providing evidence that gel fuel may indeed be a good option for cooking in certain environments, many other utilities could be examined. The possibility of using solar power especially for water heating, alternative lighting sources possibly using ethanol rather than relying on candles or paraffin and the examination into locally generated wind power are just some examples that may carry some merit into the future. The one criterion that will have to be examined is that a suitable level of sustainability is ensured. This true sustainability would need to incorporate not only the social, environmental and economic aspects of the target population but include the true integration, representation and participation of that population. The greatest value of this study lies in the fact that one of the participants who was previously unemployed now distributes ethanol gel within Joe Slovo.

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**Annexure 1**  
**BIOGEL QUESTIONNAIRE**

**GENERAL INFORMATION**

<b>NAME</b>	
<b>ADDRESS</b>	
<b>GENDER</b>	
<b>AGE</b>	
<b>EMPLOYMENT</b>	
<b>DATE</b>	

**HOUSEHOLD INFORMATION**

<b>How many people live in your household?</b>	
<b>How many visitors do you have to your household?</b>	
<b>How many people do you cook for in your house?</b>	
<b>Who does the cooking?</b>	

<p><b>What facilities do you have for cooking?</b> (primus stove, flame, 2 plate electric, 2 plate gas, micro wave, hot box, wood etc)</p>	
<p><b>What fuel do you use for cooking?</b></p>	
<p><b>How much fuel do you use?</b> (Daily, weekly, monthly)/ litres</p>	D _____ W _____ M _____
<p><b>How much do you spend on fuel?</b> (Daily, weekly, monthly) rands</p>	D _____ W _____ M _____
<p><b>Where do you purchase your fuel?</b></p>	
<p><b>What reasons do you have for using your current fuel/cooking facilities?</b> (cost, safety, access, convenience)</p>	
<p><b>What kind of food do you cook?</b></p>	<p>Breakfast: .....</p> <p>Lunch: .....</p> <p>Dinner: .....</p>
<p><b>How long do you spend cooking?</b></p>	<p>Breakfast: .....</p> <p>Lunch: .....</p> <p>Dinner: .....</p>
<p><b>Are there any safety concerns with your current cooking facilities?</b></p>	

**BIOGEL USE**

<p><b>How much gel do you use per week?</b></p>	
<p><b>How long does 1 litre last?</b></p>	
<p><b>Do you notice a difference in cooking time?</b></p>	
<p><b>How long do you spend cooking with the gel?</b></p>	<p>Breakfast: .....</p> <p>Lunch: .....</p> <p>Dinner: .....</p>

<b>Are there any meals/foods that you find the gel to cook slower or quicker?</b>	
<b>Is it more or less safe then your current cooking method? Explain.</b>	
<b>How do you feel about the gel overall? Comment openly.</b>	
<b>Is there any smell?</b>	
<b>Are there any issues that would make you not switch to Gel from your current fuel? Explain.</b>	
<b>Are there any problems with the Gel? Explain.</b>	
<b>Do you find the Gel user friendly?</b>	
<b>Do you prefer the Gel over your current fuel?</b>	

**BIOGEL STOVE**

<b>How is the stove to use? Explain.</b>	
<b>Do you like the stove? Comment.</b>	
<b>Is it easy to use compared with your current cooking appliance?</b>	
<b>Is it safe? Safer then your current appliance?</b>	
<b>Is it easy to clean compared with your current appliance?</b>	
<b>Does it store easily? Where do you keep it when not in use?</b>	
<b>What do you use it for?</b>	
<b>Who uses the stove?</b>	
<b>Does it cook as fast as your previous stove?</b>	
<b>What problems do you have with the stove?</b>	
<b>Would you switch from your current stove to the biogel stove permanently?</b>	

<b>Overall do you like the stove?</b>	
<b>Do you like the way the stove looks?</b>	
<b>What do your neighbours think of the stove?</b>	
<b>Are your neighbours interested in the stove?</b>	
<b>Are there any foods that you do not like cooking on the stove? Why?</b>	
<b>Are there any other comments you have on the stove generally?</b>	

**QUALITY OF LIFE**

<b>Do you find the stove and gel convenient?</b>	
<b>Do you ever find cooking slower than in the past? If so how much?</b>	
<b>Do you have any concerns with the stove and gel?</b>	
<b>Are there any health concerns?</b>	
<b>Is it safe to use?</b>	
<b>Are there any concerns regarding your children whilst using the stove?</b>	
<b>Do you think the fuel is cleaner than your current appliance?</b>	
<b>Do you find cooking easier or more difficult than before?</b>	
<b>Do you feel safer overall using the stove?</b>	
<b>Could you use the stove/gel for business purposes?</b>	

**COMMERCIAL QUESTIONNAIRE**

<b>How much would you be prepared to pay for Gel?</b>	1 Litre: ..... 2 Litre: ..... 5 Litre: .....
<b>What do you pay for Paraffin/Gas at the moment?</b>	
<b>What would be the most convenient size to buy Gel?</b>	
<b>How much would you pay for a Gel stove?</b>	
<b>What do you pay for paraffin /gas at the moment?</b>	
<b>What do you think of the colour of the gel?</b>	
<b>What does the colour green make you think of?</b>	
<b>Can you think of a name for the Gel?</b>	
<b>What should be put on the label of the gel?</b>	
<b>Have you shared your gel with anybody else? Who</b>	
<b>Are you going to continue to use the stove and the Gel now that you have to pay for it?</b>	
<b>Do you know where to buy Gel and what it costs?</b>	
<b>The price is R40.00 for 5l what do you think?</b>	

## ANNEXURE 2

### THE TRANSCRIPTS OF THE INTERVIEWS

In the interview dialogs

Q: Signifies Researches questions

A: Signifies Participants answers<sup>8</sup>.

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#### **Participant A: Nomande Mtana.**

Q: How many people live in your home?

A: There are 7 but we are two houses joined together. My sister lives next door and so does my mother with my sister's baby. So we are 4 here; my husband and two children. My eldest son is married and lives on the other side (Zone 31 interpreter).

Q: How much do you spend on energy a month?

A: About R250 per month.

Q: What appliances do you have? I noticed the electric cable.

A: Yes, that is illegal and comes from my cousin's house that is connected straight to the box. This helps us a lot, we cook on a two-plate electric stove sometimes but I use the paraffin stove a lot. I work 2 days per week as a domestic worker and my sister cooks more than me for the whole family. Sometimes we don't have the cable as it is cut outside the house or Eskom puts the power off or disconnects it. I also use a paraffin heater in winter for the baby and my mother in the other room. My mother is old and needs the warmth. We use paraffin lamps and candles for light and I cook sometimes outside on wood which my husband gets for free.

Q: Where do you buy your paraffin?

A: Normally at the Spaza Shop,

Q: How do you find the quality?

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<sup>8</sup> It must be emphasized that translation took place between researcher and participant as has been noted in section 3.3.6 Table 5 of this study. The interpreted text has therefore been as accurate a reading of the recipients answer as this process would allow.

A: The paraffin from the big shops is better but too expensive. I buy 25L at a time and I can't carry that from the big shop. Paraffin does not smell good when you burn it and I think that we cough more when we use the paraffin stove and the heater.

**Participant B: Veliswa Peterson**

Q: How many people live in your home?

A: Four.

Q: How much do you spend on energy a month?

A: About R150. This is mostly for cooking and here I spend about R120 on paraffin and the rest on candles. Sometimes I get connected to my friend's electricity for the radio and TV and sometimes we burn a light. This is useful for my daughter who does school work at night and says that the electric light is better than the candles.

Q: Do you only use paraffin for cooking?

A: No, I heat water for washing and use some of this water for breakfast and coffee. In the winter sometimes I will let the water simmer to keep the house warm before going to bed. We have a paraffin heater but I can't afford to use it and it is broken.

Q: Do you pay to use the electricity connection?

A: No sometimes I will baby sit in return for the favour or else I will cook for that other lady's children as she works late.

Q: How much paraffin do you buy at a time?

A: I try to buy 5L at a time but this is not always easy. If you buy from the main shop (metro – points: interpreter) you pay about R1 more but the quality is better.

Q: Where else do you buy and tell me about the quality?

A: If I buy say 1L or 2L then I must take my own container like a plastic bottle and buy from the Spaza. That paraffin sometimes it is like water and difficult to light, sometimes it smokes too much and I have even found pieces of rust in it before. The paraffin from the Spaza is dirty.

Q: How much time do you spend cooking?

A: Between 1 - 1½ hours per day:

Q: If you were offered another energy source, say gas or electricity, would you be happier to use it than paraffin?

A: Gas is no good; it is dangerous and very expensive. One day the government will give me my own house with electricity and I will be happy.

**Participant C: Nosakhe Mangaliso**

Q: How many people live in your home?

A: We are three; my husband, my daughter and myself.

Q: How much do you spend on energy a month?

A: We spend about R250 per month.

Q: What appliances have you got in your home?

A: There is my fridge which works on gas and I have a paraffin stove and a gas stove ..... (Laughs) and you are going to give me a gel stove.

Q: I believe you have been here a long time?

A: Yes, I first came to Cape Town 12 years ago from the Eastern Cape and lived with my sister in Khayelitsha but she died and when I married my husband ten years ago, I moved with him into Joe Slovo.

Q: Tell me about your experience with fire?

A: There was a terrible fire in 2005 and all my friends lost everything. They now live on the other side in the wooden houses from the government. My shack burnt but I refused to move. They say our Zone will be given proper houses soon as part of the N2 Gateway. This was the second time my shack burnt. First it happened in 2001 or 2002 and then I lost everything. Both fires were from paraffin stoves. The first one they say the people were drunk and knocked over the stove. In 2005 they say that the stove exploded. I use primus it is safer than the wick stoves.

Q: Are you not scared to use a paraffin stove?

A: Yes, but what must I do? I want a house and then I can have an electric stove.  
Paraffin is cheap.